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A.

Abey Ramsey, Mr. Ferrey on, 185
Aberdeenshire granite, 176
Adiamine link railways, 262
Adie, P., on lever balance, 7
Alabaster, uses of, 210
Allan's system of raising cables, 332
Allport, J., on coal trucks, 264
All Saints' Church, Munich, 351
Algonquin, the, 23
American railways, ballast on, 355
Amusement oils, prices in, 192
American timber, 33
American artisan, the, 311
Amsterdam Crystal Palace roof, 148
Ancient mining, 356
Anchor testing machines, 218
Ancaster stone, 4
Anglican Church, Brussels, 25
Ansted, Professor, on the division of rocks, 295
— on building stones, 210
Antwerp, Church of Notre Dame, 205
Antiquaries, Society of, 329
Apparatus for saving life, Deligne on, 361
Architectural Association, 1, 2, 27, 49, 61, 78, 91, 139, 158, 175, 187, 195, 207, 226, 245, 315, 345, 375
Architectural Museum, 17, 104, 168
Architecture of Amazed, J. Ferguson, 342
Architectural antiquities of Ireland, 95
Architectural Academy of Art, 384
Architectural competition, 336
Architectural exhibition, 163
Architectural history of Eton College, Professor Wilkes, 249
Architectural Publication Society, 163
Architectural Society of Lyons, 286
Architecture and the Industrial arts, 345
Architecture, Light and Shadow in, 158
Architecture, professor of, 185
Architecture, treatise on, B. Langley, 345
Archaeological Discovery, 184
Archaeological Institute, 249, 368
Arched Roofs, C. R. Von. Wesley, 105, 148
Archimedian Screw, 307
Argyllshire granite, 175
Armiferous springs at, 172
— armour plate of ships, 172
— armour plating of ships, 172
Armstrong gun, 332
Artistic features of Essex cottages, Rev. E. B. Corrie on, 260
Artillery, batteries to, 104
— foliage, by C. C. Colling, 22
—in relation to architecture, T. P. Seddon on, 69
Artificial stone, M. Coignet, 5
Artesian wells, 227
Artisans' dwellings, Halifax, Paul & Ayliffe, 65
Asia, the architecture of, J. Ferguson, 260
— Minor ruins of, C. Tenen & R. P. Pullan, 54
Athens, art in, 89
Atlantic telegraph, 229
— company, 111
— the, 332
— scheme, 69
Atlantic cable, observations on by T. S. Burt, F.R.S.I., 11
Australia graving dock, Williamstown, 3
—— engineering, 3
Australian timber, Shields on, 328
Automatic telegraphy, by A. Bain, 48

B

Bailly, granite columns at, 177
Baltimore, city of, 89
Baldwin, T., on riveted joints, 313
Balisto timber, 26
Banks, Sir Joseph, 329
Baron Herbst, 96
Barry, completion of palace at Westminster, 186
Barrow, W. H., roof of midland railway terminus, engine by Minton
Barnaby, N., on steel and iron rods, 282
Bat, vice, new arrangement of, L. Vale, 216
Barry, Dr. J. M., on ventilation, 124
Berengaria, in Vilette, 172
Bath stone, 4
Bath, great Coral Water, 218
Bathlin, the, 94
Batteries at office, Louthbury, 46
Batty Langley's treatise on architecture, 345
Batemant, supply of water to London, 229
Baths at Brighton, G. G. Scott, 313
Bed-rooms, planning of, 62
Belfast Harbour, Walker and Burgess, 231
Belgium, public monuments in, 217
Bel-model Bridge, H. Blows on, 364
Belfast Waterworks, 153
Bellaphone, section of, 291
Belfast, rainfall at, 171
Belgium, metallurgical industry in, 367
Belgrand, the, 179
Belcher, Messrs., insurance buildings, 185
Bellamy and Hardy, Messrs., 152
Bentley, foot by, 57
Bessemer steel, process in Sweden, 810
— H., on iron and steel, 309
Bethnal Green, houses at, 62
Bible and Thulehaut insinuates, 202
Biddulph, G. P., on level crossings, 262
—— hydraulic lift-graving dock, 321
Bignor pavement, 329
Birmingham Society, 376
Bristol Church, W. H. Croelands, 284
Bristol, station at, 76
Birkenhead Dock Works, J. M. Kondal, 218
Bishop House
Blackfriars Bridge, 229
Blackfriars, new bridge at, 177
Blackley gun, 332
Blow silhouette, S. H. Blackwell, 309
Blofield, Mr. Stamford terra cotta, 6
Blunt furnace, by D. Musch, 309
Board of Trade, 192
Boiler engine, prevention of, 265, 40, 333
—— associations, 192
—— Insurance Company, 39
— makers in Lancashire, 315
Bolsover stone
Bramma, the geology of, 222
Braidwood, on fire and fire-engines, 211
Bradfield, St. Andrew's College, G. G. Scott, 217
Breathwaite and Ericsson's, the first steam fire-engine, 212
Bramwell, F. J., on floating docks, 257
Bramley Hall stone, 7
Brazilian timbers, prices of, 302
—— specific gravity of, 302
—— railway, C. B. Lane on, 327
Brecknock, College at, 94
British association, 96, 177, 268, 281, 293, 309
—— Artists, Society of, 186
—— Architects, Institute of, 55, 180
Bridlington, T. A., on timber and deals, 27
Bridge at Blackfriars, factory, 247
Bridge arches, 281
Briou, Dr. H. E. F., iron preserving agent, 184
Bricks, Inducation of, 5
— at Babylon, 6
— Bridges in Russia and India, 347
— Blackfriars, 177
British Britannia, eight of, 327
British Museum, 20
Bristol, architects' institute of, 373
Brill's Baths, Brighton, G. G. Scott, 313
Bristol, Art Court, 268
Bridges, railway, in metropolis, 183
Brighton baths, G. G. Scott, 313
Bricks at Nineveh, 6
Bridge, Solway First, 229
Brick, advantages of, 5
Britannia carriage works, Birmingham, 75
Brothers M. A. on celestial philosophy, 95
Brussels, Church of the Resurrection, 26
Brussels, school of architecture, 217
Brewer, Sir D., on the patent laws, 82
Brunswick deals, 29
Brunei, Sir J. K., 129
Bucher's fire extinguishers, 316
Buddodness lighthouses, 248
Building act, as to thickness of walls, 5
Burnell, G. B., on the water supplies of Paris, 178
Burt, T. S., on the Atlantic Cables, 11
Barrowfield works, the, 42
Burgess, on figure drawing, 91
Burlington House, 311
Byzantine architecture, periods of, 49
—— architecture, 49

C.

Cables of suspension bridge, 215
—— testing machines, 218
Caledonian, Peruvian smoke, 340, 342
Calais Court, Broadstairs, 46
Calcareous Mortar, 10
California, hydraulic mining at, 184
Cambridge Rocks, the, 210
Canals in India, 137
Canal of Suez, 33
Canal de l'Ouro, 172
Canals, New Zealand, 13
Canning, on Atlantic cable, 113
Capitals from Cathedral Angoulême, 80
Carrickfergus, observations on the flow of water at, 171
Carriage on American railroads, 357
Carrett, W. E., coal cutting machines, 277
Carrigill, T., on railway bridge, Paris, 347
Carrigill, T., on lattice bridges 350
INDEX.

H.

Hawkney Town Hall, 282
Handbook of Formule for Architects, Hurst (rev.) 28
Harris on Mechanics as applied to architecture, 155
Hartlepool, Church of St. Hilda, 181
Hastwell on times, cements, and mortars, 10
Hawthorne's elements, 62
— on the preservation of ironwork, 234
Healy on steam power in towing, 272
Heath on the decay of materials in tropical climate, 143
Hematite pig iron, 309
Hierow's soldiers belts, 344
Height of chimneys, 200
— of Beresford, 260
Henry VII's chapel, 271
Herculaneum, art in, 89
Hero's engine, 182
Hey on the streets of London, 143
History of architecture in all countries, Ferguson (rev.) 61
High art in low countries, Dean of Ely on, 203
Hoffman on Prussian Universities, 273
Hoddinot church, 185
Holden valley, H. Jones, 186
Holte, on the homes of the working classes (1st ed.), 120
Holy Sepulchre at Jerusalem, 50
Land, the, 308
Homes of the working classes, 1
Homes of Berkshire, 260.
Hope, Beresford, on priests to art, 104
— J. B., Address at Institute of British Architects, 361
Horticultural Society Gardens, Terra Cotta at, 6
Hotel Cluny, the, 246
— Dios, Hospital of, Paris, 200; Hotel de Ville, Paris, 208
Houses for the working classes at Coventry, Doncaster, Grimsby, 64
— of Parliament, approaches to, 8
— of Commons, light of, 280
— of Parliament, reports on stone of, 226
— of Lords, light of, 280
— of Professor Kerr on, 92
— of Styles of, Professor Kerr on, 92
Humphreys, D. M., 291
Hurgin, on the spectrum of comets, 255
Number on engine sheds, 74
— on rails to engine sheds, 306
Hurst on Formule for architects, &c., 28
Huxley, on extinct orders of animals, 266
Hydraulic coal cutting machine, Garretts, 277
— lift, Murray on, 290
— lift, Readman on, 290
— lift, grading dock, Clark on, 237, 266, 269, 321
— lift, grading dock, Bidder on, 321
— lift, grading dock, 117
— ins, 10
— recirculating machine, 279
— test, 49

I.

L'Asaye, E., on the Dutch church at Austin Friars, 57
Ice producing machines, 229
Illustrations of Old Testament History, Western, (rev.) 21
Improved dwellings in London, London on, 61
Improvements in Paris, 200
Incrustation in Marine boilers, 232
India, on, in, 137
— Construction of roads in, 138
— imports from, 305
— introduction of gas into, 120
— lighthouse in, 136, 161
— railways in, 1865, 201
— The routes of communication with, Captain Tyler on, 305

Indian Tramway Companies, 118
Induction of brick, 8
Industrial Arts, the, Wyatt on, 245
Ingle on fire-proof construction, 281
Institute of British Architects, 220
Institute of Civil Engineers, 372
— of Mechanical Engineers, 200
Institution, the Smithsonian, 38
International Exhibition at Melbourne, 183
International Exhibition of Australasia, 266
Interior plating, 10
International Exhibition of New South Wales, 240
South Australia, 93
Introduction of Gas into India, 120
Ireland, Institute of Architects of, 174
Iron, its legitimate uses and proper treatment, 25
— bridges, Mann on, 326
— docks, strength of, 364
— engine-plates for railways, 86
— Fibrous, 171
— preserving agent, 184
— plates, the connection of, in shipbuilding, Basnay on, 282
— permeability of, Graham on, 220
— ships, the security of, 131
— shipbuilding, 19
— Steel, Bessemer on, 309
— steel plates, Basnay on, 282
— vessels, construction of, Lyall, 76
— work, J. H., on, at Hampton Court, Geological Museum, 243
— work at Notre Dame, Paris, Viollet le Duc on, 244
— work at Rome, 243
— work at Westminster Abbey, 243
Ipswich, Masonic Hall, 60
Irat, Town Hall, 153
Isar, Bridge over the, 355
Island of Mull Granite, 176
Italy, Railways in, 282

J.

Japanese Art, 81
Jerson on incrustation in marine boilers, 197, 232
Jones' Holborn Valley, 186
Jones' Roof of Guildhall, 186
Jurassic deposits, 172
Jux' reports, International Exhibition, 1862, 184

K.

Keene's Cement, 48
Ker, Professor, on construction, 17
Keeton stones, 4
Key cutting machine, Whitfield's, 201
Kiln Tunnel, 193
Kings' College, Cambridge, Willis on, 249
Kinas, Bridge over the, 354
Kirkham Quarries, 178
Knotty Timber, 28
Krupp's steel works, 352
Kyanised Railway sleepers, Calvert on, 326

L.

Lancashire and Yorkshire Railways, Permanent way of, Williams on, 93
Langham Hotel, the, 62
Landley's Formule for obtaining the strains of girders and roofs, 151
Laplace Bridges, Cargill on, 269
Laurie on the screw propeller, 374
Law Courts, the new, 363
Liblaine on Portland cement, 133
Lidder Water Works Company, 228
Leonardo da Vinci, 247
Leves Crossing, Bidder on, 262
Leves on ornamental iron work, 242
Lighthouse, Boddensy, 248
Light Railways, Adams on, 263
— and Shadow in Architecture, 168
— Undulatory theory of, 396

Galvanized iron, durability of, 324
Galvanometer at Brighton, 48
Gaudin on iron of the iron, 330
Gas, escape of, 69
— introduction of, to India, 120
— mains, 70
— supply of Paris, Burnell on, 65
— works at Paris, 65
Geology as applied to Architecture, Cumming on, 297, 265
— of Ramser, the, 228
German Railways, Crawfurd on, 336
— Railway system of, Crawfurd on, 353
German railways, Vignoles on, 59
Girders and stone trusses of, 161
Glasgow iron works, 42
Glass, use of, 44
Glinton Abbey, 259
Goods station, Great Northern Railway, 566
Gothic architecture, Seddon on, 90
— sculpture, Westmacott on, 271
Grantham, chemical discoveries by, 259
— on the permeability of iron, 220
— granite as a building material, 5
— granites, Cumming on, 211
— granite working, Muir on, 175
— Great on the strength of portland cement, 7
Gravestones, Symbols on, 196
— Rev. E. L. Cutts on, 195
Graving docks, cost of, 291
— Williams Town, Australia, 8
Great Eastern, the, 12
— docking of the, 297
— Indian Peninsula Company, 302
— Northern Railway goods station, 75
— Northern Railway permanent way, Williams on, 93
— greeves's pot railway sleepers, 302
— Great triangulation, the, 357
— Gun Wash, 326
— Grove on recent progress of Science, 293
— Guildhall, height of, 280
— Gun cotton, 193
— Guns, magazine of, 352
— Gutter plates, 61
— Gwynne's Centrifugal Fump, 3
— Gyapam, properties of, 281

Fuel of rail shipping, 101

G.
INDEX.

Lines, Haswell on, 10
Lining, kinds of, 4
Liverpool docks, 218
—— Docks and Warehouses, 83
—— St. George's Hall, 208
Locks, M. G., the, 65
Locomotive engines on German Railways, 386
Locomotive engines on Canadian Railways, 397
Locomotive engines on Indian Railways, 408
Locomotive engines on European Railways, 419
—— Buildings, Details of, 5
—— Chatham, and Dover Railway, 44
—— water supply, Beterman on, Hull and
—— Manchester, on, 229, 280, 331
Lunatic Asylum, Clare, Ireland, 119
Lyceum of Natural History, New York, 95
Lyell, Sir Charles, 205
Lyons, Architectural Society of, 256

M.

Macadamized roads, 188
Mc Donough's experiments in mixing air with
—— low pressure steam, 50
Machinery for tunnelling, Penrice's, 226
Machan, on the, 332
Magnetism, Airy on, 294
—— Grove on, 293
Majolica, remarks on, 44
Mallet's locomotive designs, 261
Mann on the decay of materials, 299
—— on Railway sleepers, 326
Manfield stone, 45
Manchester Architectural Association, 24
Marble as a building material, 6
Marine boilers, salt in, 198
Market Hall, Derby, roof of, 109
Market Hall, Ipswich, 50
Materials most appropriate for London exteriors,
—— 3, 43
Materials used in construction, 330
Mathews, experiments at Pisa, 46
Mathews on materials most appropriate for
—— London exteriors, 3, 43
Mauritius Railways, viaducts on, 73
Mausoleum of Halicarnassus, 51
Maw's encaustic tiles, 351
Mechanics applied to architecture, 155
Medieval metal work, 26
Grave stones, 95
Melbourne, exhibition at, 183
Memorial, the, 65
—— window to the Duchess of Kent, 186
—— to the Prince Consort, 176, 177
Menilmonument at reservoir at, 174
Merryweather's champion fire engine, 386
—— manual fire engine, 183
—— steam fire engine, 38, 213
Metals, deposition of Reservoir on, 271
Metallurgy in Belgium, 367
Metallurgical manganese, 310
Metal work, 26
—— work of Namur, 346
Methods of Painting, 187
Metropolis, Railway Bridges in the, 184
Metropolitan Fire brigades, the, 46
Metropolitan Tramway Company, the, 88
Microscopic painting, 344
Midland Railway Terminal and Hotel, designs
—— for, 27
Midland Railway, goods station, 75
—— Permanent way, Williams, 93
—— Railway, St. Pancras Station, roof of, 149
Military engineering, 332
Mill on the Craneshaugh Viaduct, 73
Minton's Bricks, 6
—— Mosaics, 361
—— tiles, 45
Model Gothic Church, Paris, 302
Montabert on painting, 189
Mont Celius Tunnel, the, 33
—— Celestial, the, 192
—— Census Tunnel Works, Sowpe on, 284
Monument to King John, Worcester Cathedral, 208
Monument of Queen Elizabeth, 271
Monuments, 191
—— Haswell on, 10
Mosaics, Salviati on, 361
—— South Kensington Museum, 351
—— the use of, 44
Mudholo, ship pieces to boilers, 360
Muir on Granite works, 175
Mural decoration, Eastlake on, 189
Museum of Practical Geology,
—— South Kensington, the, 45
Mushet on cast iron and steel, 309

N
National Gallery, the, 362
Neumeyer's powder for Blasting, 316
New dock works, Sunderland, 152
—— Law Courts, the, 9
—— Opera House, Paris, 218
—— South Wales, public works in, 280
—— Street Railway Station, Birmingham, 75
—— York, exhibition of French art in, 25
—— Zeeland Canal, 113
Niagara River, new bridge over, 116
Nineteen, bricks at, 6
Nitroglycerine, 312
Nogat bridges, the, 355
Norfolk, the churches of, 90
Norman Ecclesiastical Architecture, 80
North Eastern Railway, permanent way of, 93
Northumberland, Launch of the, 333
Norwegian works, 29
Norwich Cathedral, 90
—— Cathedral of Florence, the, 177
—— Monks chapel at, 60
Nuremberg, churches of, 91

O
Observation on the laying, Atlantic Cable, 11
Ocean telegraphy, 33
—— On the flow of water off the ground, 171
—— On the several parts of girders and roofs, 161
—— On the safety and seaworthiness of vessels, 163
Ordinance, materials for construction of, 191
Ornamental Iron work, Lewes on, 242
Oxford Museum, the stone of, 227

P
Painted decoration, Fisher on, 187
Paley's Gothic mouldings, 20
Palliser on armour bolts, 283
Papworth on roof, 92
Parc Artesen wells at, 172
—— decorations in edifices of, 120
—— demolitions in, 238
—— embankments, 287, the, 7, 27, 236, 303
—— Exhibition, weights, costs, measures, 235
—— Exhibition, catalogue of, 303
—— Exhibition, Italy, Spain, and Egypt, at the, 304
—— improvements, 6
—— new Opera House, 218
—— new public garden of, 7
—— New, 8
—— The new markets of, 7
—— water supply of, 172
—— Parts of girders and roofs, Langley on, 161
—— Passenger rates on Indian railways, 201
—— Patent concerns at stone (Ransome's) 48
—— Patent Office, the, 83
—— Patents in England, Scotland, United States,
—— Sweden, and Norway, 82
—— Peabody Buildings, 186
—— Peninsular and Oriental Steam Company, 306
—— Penrose on St. Paul's Cathedral, 186
—— Permanent way, maintenance of, Williams, 93
—— Permeability of iron, Graham on, 220
—— Perth, Sewerage of, 88
—— Pennamuck Railway, 299
—— Peckham granite, 176
—— Petroleum as steam fuel, 84
—— Philadelphia docks, 237
—— Pine, yellow, 32
—— Pink granite, kind of, 126
—— Pneumatic Railway under the Thames, 193
—— Poly, arsenal of, 261
—— Pompeii, art in, 89
—— Poplar, 206
—— Portland cement, Liblano on, 133
—— cement, Haskahow on, 62
—— cement, manufacture of, 7
—— stones, 47
—— Pottery, 44
—— Powder for blasting, Neumeyer on, 316
—— President's address, Institute of civil engineers,
—— Prince Consort's Memorial, 176, 177
—— Prior Crucinian's chapel, 207
—— Priory of St. John, Kilkenney, 95
—— Prize to art works on, 104
—— Procedure to repair Atlantic Cable, 111
—— Profession, Architectural, and the public,
—— Lanyon on, 174
—— Professor Kerr on architecture, 95
—— Phillips on celestial photography, 95
—— Progress of Engineering, 373
—— Proposed new Courts of Law, Webster on, 9
—— Prussian Railways, 171
—— Public monuments in Belgium, 217
—— Works in New South Wales, 280
—— Pugin, travelling studentship, 366
—— Quarries at Kirkmarbrook, 176
—— Quarterly Journal of Science, 97
—— Queen Phillips, Tomb of, 269

R.

—— Raft ship, buoyant packing of, 10
—— ship, hull of, 102
—— Raft shipping, Atherton on, 19
—— shipping, practical construction of, 100
—— Rafters, light, 61
—— Radiation and absorption, Tindall on, F.R.S.,
—— 13
—— Rail, the Vignole, 34
—— Railway arches as dwellings, Emmanuel on, 341
—— bridge, in Paris, Cargill on, 347
—— bridges in Metropolitan, 184
—— the Cologne, Mindin, 171
—— Carriages in Russia, 376
—— Carriages, 120
—— curves, Crawford on, 338
—— enterprise in Italy, 282
—— for horse power, 138
—— gradients, 338
—— Hotel, the St. Pancras, 154
—— in Germany, Crawford on, 353
—— Indian, in 1865, 201
—— in London, 190
—— in Russia, 310
—— iron engines pits for, House on, 86
—— London, Chatham, and Dover, 44
—— over Mont Cenis, 307
—— Passengers in India, 162
—— Prussian, 171
—— Sheds, W. Humber on, 368
—— Speed on, 192
—— Station, St. Pancras, 194
—— system of Germany, Crawford on, 336
—— The Festingway, 221, 261
—— cost of, 221
—— permanent way of, 221
—— Captain Tyers' report on, 221
—— the permanent way of, Richardson on, 129
—— Viaducts, 338
—— Wagon, 320
—— wheel, Smith on, 312
—— Rainfall at Belfast, 172
—— Rankine on ship building, 191
—— on friction, 296
—— on the tenacity of some fibrous sub-
—— stances, 38
—— Ransome's concrete stone, 6, 330
—— process for coating stone, 4
INDEX.

Recent progress of science, Grove on, 253, 293
Redgrave in bright of rooms, 311
Rembrandt, paintings of, 206
Rendel on Dockworks at Birkenhead, 218
Rennie, G., C.E., Memoir of the late, 149
Repairing Hope, Humber on, 74
Reports on stone, Houses of Parliament, 226
Reservoir at Murlointon, 172
Restoration of the Dutch Church, Austin Friars, 29
Reuben, paintings by, 205

REVIEWS—

Ahmedabad, architecture of, Ferguson, 342
Art foliage, C. K. Olling, 13
Asia Minor, principal ruins of, Texier and Pullan, 115
Fire, fire engines, and brigades, C. T. F. Young, 245
Handbook of formulas, Hurst, 13
History of architecture in all countries, J. Ferguson, 61
Homes of the working classes, J. Hale, 58
Illustrations of Old Testament history, Westlake and Purdue, 11

Mansions, lodges, villas, &c., F. Rogers, 310

Rivett's Joints, Baldwin on, 313
Reynolds, Sir Joshua, Discourses, 19
Rhine, bridge over the, 565
Richardson on the permanent way of railways, 129
Cathedral of St. Paul's, Penrose on, 188
Ridley on viaducts, 73
Ridgeway, 190
River Merne, the, 172
Roads in India, 114
Road of William显port suspension bridge, Beller on, 216
Roberts' fire engine, 214
— gig engine, 183
Robertson's frictional screw motion and application, 41
Rock boring drill, 184
— boring machines, 193
Rodman gun, the, 332
Roeder, stone bridge over the, 358
Rogers on English mansions, villas, &c., (rev.) 310
— Professor, 60
Roman cement, 7
Romans in art, 229
— churches of, 91
— excavations at, 120
Romney Abbey, Ferrers 185
Roads, construction of, India, 138
— and Railways in India, 161
— and Railways in India, Sir W. Denison on, 136
Roads, arch'd, Wessely on, 148
Roof, Crystal Palace, Amsterdam, 148
— Crystal Palace, Sveden, 160, 107, 216
— Derby Market Hall, 109
— Dublin Exhibition, 198
— Guildhall, London, Jones on, 156
— Midland Railway Terminus, Barlow on, 27
Romulo, sculpture by, 272
House on iron engine pits for railways, 86
Royal Academy, architecture at, 186
— Academy, the, 377, 378
— Astronomical Society, 96
— Insurance Buildings, Belcher, 186
— Society of Edinburgh, 82
— Society of London, 92
Rubble Masonry, Heath on, 323
Russin on Venice, 90
— stones of Venice, 19
Russell, J. Scott on, shipbuilding, 191
— on graving docks, 221
Russian shipway carriages, 376
Russio American telegraph, the, 372
Rutherford on celestial photography, 97

S.

Safety valves, Hiller on, 40
Salisbury Cathedral, granite columns at, 177
Sails in marine boilers, 198
Salviati on Venetian mosaics, 361
San Domingo mines in Spain, 266
Sanitary improvements of Edinburgh, 88
Scaglioni, 44
Scott, G., Bralla Ratha, Brighton, 318
— College at Bradford, 217
— Remarks on concrete floors, 283
— Restoration of St. David's Cathedral, 253
Scottish Plate Company, 177
Screw motions, Robertson on, 41
— propeller, Laurie on, 374
Scriveners Majolica tiles, 45
Sculpture in Westminster Abbey, Westminster on, 219
Sea wall, Boston Harbour, 11
Seddon on Breeon college, 94
— on art in relation to architecture, 89
Seine, water of, 172
Serpenyne, 5
Sewage of Perth, 58
Shank of fire engine, 188
— first steam fire engine, 213
Sharpe's Paralys, 19
Shields on graving docks, 202
— on Australian timber, 328
— on bridges in Pernambuco, 327
Shipbuilding, timber for, 303
Ships' compasses, correction of, at sea, 32
Siemen's regenerative furnace, 255
Silk flake, tenacity of, Rankine on, 36
Silurian Rocks, 210
Silver thread, tenacity of, Rankine on, 36
Simons on the safety of vessels, 165
Sir Charles Fox on railways, 223
— on graving docks, 257
Slide as a building material, 44
Smith on railway wheels, 312
— on study, as a preparation for practice, 18
Smithsonian Institution, the, 38
Smith's Museum, 17

SOCIETIES—

Archaeological Institute, the, 249
Architectural Association, the, 24, 27, 49, 61, 78, 91, 139, 153, 168, 178, 187, 207, 228, 242, 249, 315, 354, 375
Architectural Society of Lyons, 236
Birmingham Society, the, 370
British Architects, Institute of, 160, 220
British Association, the, 277, 281, 293, 309
Civil Engineers, Institute of, 7, 8, 33, 66, 70, 171, 194, 204, 205, 289, 289, 292, 324, 326
Civil and Mechanical Engineers, 330, 200
Essex Architectural Society, 260
Engineers, 31
Engineers Ireland, 190, 229
Engineers in Scotland, 374
Institute of Architects in Ireland, 174
Royal Academy, the, 91, 311, 376
Royal Astronomical Society
— Royal Society of Edinburgh, 82
Royal Society of London, 86

Society of arts, 65, 175, 352
— of British Artists, 186
— of Engineers, 35, 197, 313
— of Scottish Engineers, 41
Social Science Association, 341, 338
Soldiers, new belt for, 344
Somerset House, stone of, 4
Southern embankment, Thames, 367
South Easterly railway, permanent way, Williams on, 93
Southwark bridge, 143
South Kensington Museum, 365
Spanish railways, 247
Spruce deals, 29
Staichliff Church, Yorkshire, 381
St. David's Cathedral, restoration of, 252
— John's Church, Wolverhampton, J. D. Wyatt, 311
— John's College, Hurstpierpoint, 185
— Marks, Venice, 60

St. Mark's, facade of, 351
— Dome on, 184
— Mary's Church, Kilkenny, 95
— Nicholas Church, Yarmouth, piers, south porch, windows, 90
— Paul's Cathedral, 24, 60
— Saviour's, Southwark, 20
Steam boiler explosions, 369
— dredges, 308
— ferries, 229
— fire engine, 36
— power doubled without additional fuel, Ewbank on, 216
— power in heating, Healy on, 372
— power in towing vessels, Clausram on, 372
— tugs on the Severn, 372
Steel works in Prussia, 352
Steinhil on Telegraph, 48
Stephenson, Robert, 65
Sterechromic painting, Dr. Fuchs, 188
Stevenson, Allan, 119
St. John's deals, 29
Stone bridges in Germany, 353
— report on House of Commons, 4
Stores of raft shipping, 102
Steam gages, 171
Streets of London, Haywood on, 142
Street's Church, Leamington, 185
Strength of cements, 330
Sunderland, Dock Works, 152
Surface condensers, 199
Surmellen aqueduct, 172
Sutherland, steam fire engine, 36
Syria, art in, 185

T.

Tall on concrete walls for cottages, 250
Taunus Railway, 355
Telegraphic system in China, India, America, 225
— Telegraph office, Lothbury, 46
— the Atlanta, 69
— the Russo-American, 372
— Temple Church, tomb in, 198
— Tennant, Professor, 177
Terra Cotta, Blackfield's, 6, 45, 110
Tesselated Pavement, Eastbourne, 329
—they Embankment, 146, 177, 293
— Graving Docks, 237
— the water of, 229
The connection of plates of iron and steel in shipbuilding, Barnaby on, 185, 282
— The Moon, photographs of, 97
Thomson on molecular friction, 36
Theoretical element of raft shipping, 100
— theory of influence of friction on mechanical efficiency of steam, Rankine on, 296
Thorncife, church at, 118
Tiles, encaustic, 44
Timber, American, 32
— Baltic, 28
— and deals, Brinton on, 27
— drying, Davison Lymington, 29
— in the log, 26
— knots, 28
— trees, Brinton on, 27
Tetian company, 310
Tolls on bridges, 143
Torrorm Quay, 85
— Towers of suspension bridges, Boller on, 215
— Town Hall, Farnham, 110
— Hall, Ipswich, 152
— Tracton engine, Paris, 282
— Trafalgar graving dock, 200
— Training for civil engineers, 71
— Trees, age of, 29
INDEX.

Trial of steam fire engine, Field, 250

Tuileries, Palace of, 200

Tunnel Mont Cenis, 33

— Straits of Dover, 193

Tunneling, Sommiller's system, 285

Tunnels in Germany, 353

— iron framing for, 193

Turner on Archæology of Eastbourne, 329

Turkish platen, 10

Tyler on the Routes to India, 305

Tyndall on radiation and absorption, 132

— Professor, on Heat, 295

U.

Unger, Professor, on Egyptian bricks, 280

United Service Institution, 100

Universities, Cambridge, Oxford, 71

Ure on salt in solution, 198

V.

Vandyck, paintings by, 205

Vartry water works, 292

Vase cement, 172

Venice, art in, 90

— stones of, Ruskin, 90

Ventilation, 82

— Edmunds on, 124

— Barry on, 124

Vernon on strength of vessels, 77

Vessels, safety and seaworthiness of, Ferguson on, 127

— safety of, Simens on, 163

Viaduct, Croisellachie, Mills on, 73

— Mauritius Railway, Ridley on, 73

— Viaducts in Germany, 353

Victoria Docks, Bidder on, 237

— Station, Pellico, 75

Vignoles on railways, 357

Vignoles railways, 259

Vilett, basint at, 172

Voilant de Duc's Dictionnaire, 19

— le Duc, ironwork, 244

W.

Warehouses, Liverpool, 33

Waste of Coal, 311

Water glass painting, 187

Waterloo bridge, pavement of, 177

Water, storing of, 62

— supply of Paris, 172

Waterwitch, the, 38

Waterworks, Leeds, 228

Watt, James, 162

— Waugh on decay in timber, 326

Wellesley, quarterly papers, 291

Wedgwood, 44

Wells, Artesian, Paris, 172

Westleyan College, Belfast, 152

Wessex on arched roofs, 165, 148

— on roof of Crystal Palace, 216

Westlake Illustrations of Old Testament History, 21

Westminster Abbey, 20

— Abbey, monuments in, 267

— Abbey, sculpture in, Westminster on, 219

— the Chapter House, 49, 366

— Palace, 185

Westminster on the sculpture in Westminster Abbey, 219, 287

White Tower, the, 20

Whitehead's key cutting machine, 201

Wilkerson on color, 168

Williams on permanent way, 93

Williamson suspension bridge, 215

Williamstown graving dock, 3

Willis on Architectural history of Eton College, 249

Willis on King's College, Cambridge, 249

Winchester Cathedral, tomb in, 196

Window tracery, 90

Wisbech, Industrial Exhibition, 203

Wiseman, Cardinal, 63

Wolverhampton church, 311

Woodburn river, 172

Workhouse, St. Mary, Islington, 50

Working classes, homes of, Bradford, 64

— classes, homes of, James Hall (rev), 54

Workmen's dwellings, West Hill Park, Halifax, 1

Workshops, Stewarts Lane, Bishops Road, Nine Elms, 75

Wrought iron in London exteriors, 8

Wurtemburg, Railways, 309

Wyatt on architectural taste, 257

— on encaustic tiles, 44

Y.

Yale, L., on the bar rice, 37

Yellow Fever, 32

Young on first fire engines, 245

Yorkshire stone, 4

Z.

Zinc, use of, 44

LIST OF PLATE ENGRAVINGS.

Plate

1. Model Dwellings for Artizans, West Hill Park, Halifax, Yorkshire; Paull and Ayliffe, architects.

2. Ditto, Block plan.

3. Ditto, Front elevation and general plan.

4. Ditto, Front elevation; chamber, ground, and cellar plans.


6. Church of the resurrection, Brussels; Interior of

7. Nave, looking north; R. J. Withers, architect.

8. Frictional screw, motions, and appliances; Robertson's.

9. Font in St. Mary's Church, Winkfield, Berks; John F. Bentley, architect.

10. Font in St. Mary's Church, Barbados, W.I.; John F. Bentley, architect.

11. Early French capitals, from the Cathedral of Angouleme, and the Church of St. Front, Perigueux.


13. Church's College, Brecon; Perspective View and Ground plan; Prichard and Seddon, architects.

14. New Church, Thorncliffe, Sheffield; Wilson and Wilcox, architects.

15. Roof of the Centre Transept, Crystal Palace, Sydenham.

16. Roof of the Dublin Exhibition; Ordish and LeFevre, engineers.

17. Roof of New Market Hall, Derby; Ordish and LeFevre, engineers.


20. Victoria Docks, Bidder on, 237

21. Station, Pellico, 75

22. Vignoles on railways, 357

23. Vignoles railways, 259

24. Vilett, basin at, 172

25. Voilant de Duc's Dictionnaire, 19

26. le Duc, ironwork, 244

27. Warehouses, Liverpool, 33

28. Waste of Coal, 311

29. Water glass painting, 187

30. Waterloo bridge, pavement of, 177

31. Water, storing of, 62

32. Water supply of Paris, 172

33. Waterwitch, the, 38

34. Waterworks, Leeds, 228

35. Watt, James, 162

36. Waugh on decay in timber, 326

37. Wedgwood, 44

38. Wells, Artesian, Paris, 172

39. Wesleyan College, Belfast, 152

40. Wessex on arched roofs, 165, 148

41. Wells on roof of Crystal Palace, 216

42. Westlake Illustrations of Old Testament History, 21

43. Westminster Abbey, 20

44. Abbey, monuments in, 267

45. Abbey, sculpture in, Westminster on, 219

46. Abbey, the Chapter House, 49, 366

47. Westminster Abbey, 185

48. Westminster on the sculpture in Westminster Abbey, 219, 287

49. Illustrations of Mechanics applied to Architecture; R. O. Harris.

50. Houses for the working classes, Akroydon, Halifax.

51. Ditto; elevation and block plan.

52. Ditto; ground, cellar, and chamber plans.

53. Details of ironworks of roof of Crystal Palace.

54. Sydenham.

55. St. Andrew's College, Bradford; general perspective view.

56. Ditto, ground plan.

57. The hydraulic lift graving dock, Victoria Docks.

58. London; elevation, plan, and details.

59. Museum and library, Queen's road, Bristol; perspective view; Foster and Wood and A. C. Ponton, architects.

60. Ditto; ground plan and first floor plan.

61. Cottages for agricultural labourers and workmen; concrete walls, floors, and roofs, perspective view, plans, and sections.

62. Tall's patent apparatus for constructing buildings of concrete.

63. Christ Church, Staincliffe, Yorkshire; perspective view; W. H. Crossland, architect.

64. The Parish Church, Brislington, Yorkshire; perspective view.

65. Brill's baths, brighton; exterior view; George Gilbert Scott, R.A., architect.

66. Ditto; interior of swimming bath.

67. Railway Bridge at Place de l'Europe, Paris; plan, sections, and details.

68. Ditto; sections of struts and ties; details.

Opposite page

165

167

167

167

215

215

217

217

237

249

249

251

251

251

284

313

313

317

350
Artsizns' Dwellings,
West Hill Park, Kilburn.

Front Elevation of Houses in Class 8.

Back Street

General Plan of Two Blocks of Houses in Class 8.
Artizans' Dwellings, West Hill Park, Halifax.

Chamber Plan, Class No. 4

Ground Plan

Chamber Plan, Class No. 8

Plan of Cellars to Houses, Class 4

Plan of Cellars to Houses, Class 8

Faulk & Ayliffe, Architects, Manchester.

J.H. Jobbins.
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

TO OUR READERS.

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

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

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

WORKMEN'S DWELLINGS, WEST HILL PARK, HALIFAX.

(With Engravings.)

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

Mr. Holesays the object is "to encourage thrifty artisans, clerks, and others to obtain freehold dwellings for themselves. In 1862 Mr. Crosley purchased a very eligible plot of land in the suburbs of Halifax, bounded by the parallel thoroughfares of Gibbet-lane and Hanson-lane. Invitations were sent to the local architects, and also to Messrs. Paul and Ayliffe, of India-buildings, Cross-street, Manchester, offering premiums for the best designs for laying out the land, and for the houses in each class of dwellings. The plans were publicly exhibited, and the first premium was unanimously awarded to the Manchester architects. A reference to the 'block plan,' see Plate 2, will show the principle adopted in the laying out. Streets with through communications pass at right angles from Gibbet and Hanson lanes each side of the land; therefore cross streets were made in connection with them. These are given in the centre of the plot, and are each 40 feet wide. The ground rises rapidly from east to west."


* In our next we shall give Plates 3 and 4, which will show the skilful internal arrangement of the West-hill Park dwellings.
west, but is nearly level crossways; therefore the houses are chiefly disposed in long rows from south to north. The spaces between the fronts of the respective rows not being required for vehicles, old gardens are giving a public causeway in the centre 5 feet wide, and neat iron fencing to enclose each garden. Opposite each end of each front space, a street opens out into the highway, and gives facility for access by carts, &c. to the streets at the back of the houses. Public view of back streets is not desirable, therefore short blocks of houses are provided on street-side and backlanes, which render them in this case comparatively private. By this arrangement the occupants of the dwellings have every inducement to keep the fronts of their houses neat and tidy,—all unsightly but necessary operations being confined to the back, and shut out from the public eye.

It was originally intended that the houses in class No. 4 should be erected for about £100 each, exclusive of land, streets, sewers, and architect's commission. It was found, however, that the desired accommodation could not be obtained in substantial buildings for such a small amount as this; and the cost was therefore fixed at £150. Notwithstanding their increased value, the idea of 'cottages' still attached itself to the dwellings in this class; and the arrangements were planned accordingly. A spacious family living-room next the front, and a good scullery at the back, a small cellar below, and three bedrooms above, seemed to furnish every requisite for an artisan's family; but now that the houses have been taken up and occupied, it is found that the inhabitants are of a higher class of interests than any other class. He is not only enabled to do this, but to capitalise his future rent, and make each payment of it accumulate at compound interest.

The advantage is really greater than thus stated. In practice it would be difficult for a working man to invest £40 at 6 per cent., in the stock of a railway, &c. in such a manner as to accumulate interest to the extent of £19 in 12 years, when principal and interest are paid. This makes £55 4s. a year, which has assisted to make the above payments, and must therefore be deducted

| Amount furnished by purchasers | £60 0 0 |
| Interest at 6 per cent. thereon | 3 0 0 |
| Amount of cost of dwelling | 119 4 0 |
| Total cost | 160 0 0 |

Thus he obtains for £119 a dwelling worth £180, besides the use of a superior dwelling twelve years sooner than he could otherwise expect to secure it.

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abundance through sickness, and still more by their idleness and wastefulness, the result of their low moral feeling and want of self-respect. Large factory owners have often admitted that whatever they have spent in improving the education and social condition of their workpeople, has been a most profitable investment; and surely, among all the positive conditions of improvement, none are so powerful as a clean, comfortable, and healthy dwelling.

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

MATERIALS MOST APPROPRIATE FOR LONDON EXTERIORS.

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

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

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

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

The present value of ground in London, and especially in the City, bears no proportion to its value formerly. Then, the annual value of the building was determined by the cost of the erection, with a comparatively small addition for ground rent. Now, the reverse is the case, and the capitalist has to calculate the amount of rent he is likely to obtain by the occupation of every available portion of land taken as an example. The site has a very narrow frontage, and that in an equally narrow street, the adjoining and opposite houses having ancient light, which must be respected in order to avoid threatened injunctions, or claims for compensation for diminished light and air. As much light must be obtained in the building itself as is possible. Every
inches of space must be economised; and as the Commissioners of Sewers scarcely allow an inch projection on the public way, there is a great architectural prejudice in.

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

What then is to be done? Light being so essential, the new building must have no extremely prominent parts casting their deep shadows over the upper portions of the windows, and thus the whole of the given magnesian limestone is utilised in open spaces, and which contributes so largely to the author's design, cannot be obtained for him in a city street. The architect, deprived thereby of the opportunity of giving relief to his design by the contrasts of light and shadow, is compelled to resort to some means by which the otherwise extreme simplicity and plainness of the front of his building may be relieved, without the use of stone as the general design. This relief may be obtained by a judicious use of materials that not only possess, but retain pure and brilliant colours. The consideration therefore of the materials best adapted for London exteriors, both for durability and appearance, may well form the subject-matter of an essay at a time like this, and it is in the absence of the stone that turns little to it into two parts, viz., constructive and superficial. In the former will be comprised those materials which form part of the structure, as stone, brick, wood, iron, &c., and in the latter, those which are applied after the building is erected, as cement, encaustic tiles, and other ceramic manufactures, mosaic, &c.

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

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

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

Limestones are of two kinds: the carbonate of lime, and the carbonate of lime and magnesia. The former comprises amongst others the oolitic stones of Portland, Keeton, Anzaster, and Bath. The latter includes the stones of Yorkshire, Derbyshire, Bolsover, Mansfield, and others. If it could be ensured that in a marble more than limonite were present, the carbonate of lime and carbonate of silica, they would be valuable, but for want of this they often prove very treacherous, as is evidenced by the stone used in the Houses of Parliament, which is from the Asson quarries in Yorkshire, and was considered to be impenetrable. The Bolsover stone in Derbyshire, which occupies a high place in magnesian limestone both theoretically and practically, but on account of the beds being too thin was considered useless in building the Parliament Houses. In reporting on the decay of the stone used, the committee appointed by the House of Commons states, that it is obvious that, although some in the stone system to stand, the most excellent and durable material when not exposed to the deleterious influences of a London atmosphere, yet that in London it is subject to causes of decay which render it an undesirable and unsafe material for the construction of public buildings. The same committee in speaking of Portland, says, "It is equally obvious, that Portland stone has been used in London to the date of St. Paul's downwards, and under circumstances of great exposure, and with most successful results. Portland stone is a material to be obtained in any quantity, in blocks of any size, beautiful in colour and texture, reasonable in price, not by any means as hard as Ancaster stone, and yet with a power of resisting the action of the weather so excellent, that it can be laid without much labour and making the cleanest job when completed." Portland has not only the advantage of being the most lasting stone, but also in being capable of sustaining a greater weight than almost any other. Tiabury stone is a good limestone. Bath stone, although justly celebrated, is scarcely to be depended upon for London buildings. If it were possible for stone to be quarried, and worked some months before they are set, there would be far less decay, as the outer surfaces would so harden as to prevent the entrance of rain and frost to a considerable extent.

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

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

In designing a stone building breadth should be studied as much as possible, as nothing looks more unsatisfactory than narrow stone piers, which at once denote apparent weakness in that material, which ought most of all to give the appearance of solidity and strength. Intimately associated with sand and limestone are those older and harder materials, granite, and serpentine, and also marble, which lend so great a charm, and often brighten up a design that would otherwise be cold and cheerless, and which also offer so ready an escape for the evil just complained of, in using a narrow stone pier, by substituting a column of stronger material, whereby no room is lost, and a far more pleasing and satisfactory effect is obtained.

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

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

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

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

Many experiments have, from time to time, been made, and patents obtained, for the manufacture of an artificial stone, by which science endeavours to make up the deficiency existing in natural building stones. The attempt is made constantly for a stone which renders the process expensive; and, unless great care is bestowed, the materials will be imperfectly burnt; and, when moulding and other delicate portions are required, are very liable to twist in the process.

M. Coignet manufactures an artificial stone, composed of sand, grey lime, and Portland cement, mixed with a little water, and allowed to consolidate in moulds. This material has been in use largely in France since 1858, and a church near Paris is said to be entirely built of it. This process seems a difficult one, and its success must depend on the proper slaking of the lime, and the purity of the Portland cement,—difficulties in London, at least, almost insurmountable.

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

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

The manufacture is more ancient than that of brick, and it is worthy of remark that, in whatever country clay was found, its buildings were generally of brick rather than stone; and it is surprising, considering its extensive use, the art of brickmaking has not, until quite recently, taken its proper position among the arts and sciences.

Modern times have lately been done in the way of improving both the material and the setting, but there is still much remaining to be done; but at the present time, when such millions of bricks are being consumed by our great engineering works, it is probably too much to expect; but if some manufacturer could be found, willing to take up the matter as an art, he would expend all his efforts with success.

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

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

The size of the bricks is a great impediment in design, for although most useful in carrying out the requirements of the Building Act as to the thickness of walls, it may be insisted that buildings should be adapted to climate, and that this is shown by the disproportionate forms adopted in many buildings, whereby the effect is sought to be obtained wholly by coloured brick. So long as this will be allowed to exist, so long will buildings lack that purity of form so distinguishable in those of the ancients.

The correct form and proportion must be primary; ornament, colour, and decoration are (though important) secondary considerations.

While the Act of Parliament was in force restricting bricks to one size, we can readily understand why no endeavour was made to alter it; but now that it is altered, it is a matter of regret.
that other sized bricks, capable of being worked in with the common stocks, are not more generally manufactured. Bricks of about the thickness of tiles could be very advantageously used as bands, and often with better effect than the ordinary course of bricks. To borrow a suggestion from Mr. Halsey contained in his lecture before the Association, "Bricks 134 to 9 or 9 to 12 1/2 would afford a good opportunity for a sunk ornament being stamped, and filled in with a clay of another colour, and burnt together;" or even stamped without the introduction of the filling, and in a variety of other ways.

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

It is with great difficulty that a brick-front is worked neatly without the aid of tuck-pointing; this is, or ought to be, inadmissible, especially where colour is used, as it seriously cuts up the design, and destroys all breadth and harmony. When bricks are used as projections in string-courses, pilasters, &c., they ought to be plain, height and width, and the mortar washed off by the rain, becomes a paste, and fills the pores of the brick with the coating previously hanging on it; therefore, notwithstanding that a brick front may, when finished, satisfy the admirers of colour, yet after a time the whole effect is lost, the bricks soon losing their colour, and darkening unequally; this is especially observable where red bricks are used in combination with white or yellow marl—a former being frequently pressed, and consequently not so porous as the latter, retain their colour for a much longer period.

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

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

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

PARIS IMPROVEMENTS.

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (in Francs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public promenades and plantations</td>
<td>1,200,000</td>
</tr>
<tr>
<td>Water supply and sewerage</td>
<td>1,820,000</td>
</tr>
<tr>
<td>Religious edifices, hospitals, municipal buildings</td>
<td>2,400,000</td>
</tr>
<tr>
<td>and public schools</td>
<td></td>
</tr>
<tr>
<td>Road work</td>
<td>5,000,000</td>
</tr>
<tr>
<td>Total</td>
<td>8,000,000</td>
</tr>
</tbody>
</table>

Of all the public works the sewers are beyond question the most important and the most difficult of execution, and the progress which has been made during the last few years, not only in the extension but in the improvement of the system of these great outlets of impurity is one of the most important facts in the history of Paris. It is in 1803 (in the year 1803), the total length of all sewers of the city was 15,386 metres. The additions since have been as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Length of Sewers (in metres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1803</td>
<td>15,386</td>
</tr>
<tr>
<td>1812 to 1831</td>
<td>20,124</td>
</tr>
<tr>
<td>1832 to 1839</td>
<td>50,870</td>
</tr>
<tr>
<td>1840 to 1847</td>
<td>27,804</td>
</tr>
<tr>
<td>1848 to 1849</td>
<td>9,925</td>
</tr>
<tr>
<td>1850 to 1855</td>
<td>21,788</td>
</tr>
</tbody>
</table>
As a preliminary step, samples of Portland cement were obtained from all the principal manufacturers for the purpose of experiment. The average weight of cement of these samples, when cured for 1 month in a bushel, and they sustained breaking or tensile strains, at the end of a month, varying from 75 lb. to 119 lb. upon a square inch. A clause was then inserted in the specifications to the effect that the Portland cement to be used in the works should be guaranteed as follows: ground extremely fine, weighing not less than 110 lb. to be used in the bushel, and capable of resisting a breaking weight of 400 lb. upon a square inch, seven days after being made, and meeting the requirements for the ten days. The standard was subsequently raised to 500 lb. on the same sectional area, which was that used throughout the experiments. During the last six years, 70,000 tons of Portland cement had been used in these works, weighing over 261,000 bushels, and costing $1,250,000. This quantity of cement had been submitted to about fifteen thousand tests, at a cost of only five farthings per ton. The machine devised for testing the tensile strain was a lever balance, constructed by Mr. P. Ainslie (Asso. Inst. C.E.), and its first cost was from £10 to £20. It was so simple that an ordinary workman could be trained to test the cement, and the cost for labour did not exceed 20d. per annum for each machine.

The manufacture of Portland cement required extreme care in the admixture of the two simple and well-known ingredients, clay and chalk, it being necessary to vary the proportions according to the quality of the chalk; thus, in white chalk districts, the clay formed from 25 to 30 per cent. and in grey chalk districts from 40 to 45 per cent. of the whole burnt mass. The raw material was then taken on board the banks of the rivers Thames and Medway: the clay, which should be as free from sand as possible, being obtained from the creeks and bays between Sheerness and Chatham. Long experience has enabled the clerks of works to detect the perfections of the material both by weight and by weight. Very strong Portland cement was heavy, of a blue-grey colour, and set slowly, in fact, the longer it was in setting the greater was its strength. Quick-setting cement had generally too large a proportion of clay in its composition, was brown in colour, and turned out weak, if not useless. In May, 1866, the price per bushel was 8d., and per bushel was inserted; but this was far above its present market value.

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

The results as a rule were the average of ten tests, the samples being immersed under water from the time of setting to the time of testing. The tables showed that, during the last six years, 1,369,210 bushels of Portland cement had been submitted to 11,514 tests, and that the average strength of the Portland cement, 114.5 lb. per bushel, and to possess an average tensile strength of 508 lb. upon a square inch, being 514 and 21 per cent. in excess of the two specified standards. It was also ascertained that, provided Portland cement be kept free from moisture, it would, if not kept in casks or in sacks, but rather improved by age—a great advantage in the case of cement which had to be exported. Experiments, conducted over periods varying from one week to twelve months, with Portland cement, weighing 112 lb. to the imperial bushel, gained next and mixed with varying proportions of different kinds of sand, showed that neat cement was stronger than any admixture of it with sand; that mixed with an equal quantity of sand (as had been the case throughout the Southern Main Drainage Works); the cement was not to be the same as the neat cement, approximately three-fourths of the strength of neat cement; that with two, three, four, and five parts of sand to one of cement the strength was respectively one-half, one-third, one-fourth, and about one-sixth that of neat cement. Other experiments showed that twelve months' neat cement was about one-third stronger than that which was out of water, both indoors and exposed outside doors to the action of the weather; that blocks of brickwork, or concrete, made with Portland cement, if kept under water until required for use, would be as strong when dry as when wet; and that salt water was as good for mixing with Portland cement as fresh water. Bricks made from Portland cement, after being made three, six, and nine months, with or without a crushing force of 55, 92, and 102 tons respectively, were equal to the strength of ordinary brick. Bricks and blocks of cement mixed with four and five parts of sand, were a pressure equal to the best picked stock bricks; while Portland stone of similar size, bore on its bed a crushing weight of 47 tons, and against its bed it bore a crushing weight of 53 tons, and against its bed 64 tons. Portland cement concrete made in the proportions of one cement to six or eight of ballast, had been extensively used for the foundations of the river wall and the pier of the

INSTITUTION OF CIVIL ENGINEERS.

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

This communication related to an extensive series of experiments, the results of which were recorded in voluminous tables forming an appendix to the paper, carried on during the last three years, with the object of ascertaining as far as possible that only cement and other materials of the best quality should be employed in the Southern Main Drainage works, of which the author had charge as resident engineer.
reservoirs at Cresness, as well as for the foundations generally both there and at Deptford, with the most perfect success. It was thought that it might be still more advantageously used as a substitute for brickwork or masonry, wherever skilled labour, whether the imported masons or foreign foundations had to be made with the least expenditure of time and money.

Whenever concrete was used under water, care must be taken that the water was still, as a current, whether natural or caused by pumping, would carry away the cement and leave the impression of the water. Foundations had to be made with the least expenditure of time and money. Whenever concrete was used under water, care must be taken that the water was still, as a current, whether natural or caused by pumping, would carry away the cement and leave the impression of the water. Foundations had to be made with the least expenditure of time and money. Whenever concrete was used under water, care must be taken that the water was still, as a current, whether natural or caused by pumping, would carry away the cement and leave the impression of the water. Foundations had to be made with the least expenditure of time and money. Whenever concrete was used under water, care must be taken that the water was still, as a current, whether natural or caused by pumping, would carry away the cement and leave the impression of the water. Foundations had to be made with the least expenditure of time and money.

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

The Annual General Meeting.

Dec. 19, 1865.—It was remarked in the Report of the Council, that the institution must be allowed to modify its subscriptions to all its members, and eminently so to those few still living who, many years ago, when young men, laboured earnestly to secure for it a recognised place among the scientific societies of the Metropolis. They seemed to have anticipated that, as many of the friends of science would continue to use the Institution as a place of instruction and recreation, the annual subscription might essentially be considered as a way of paying 10s. 6d. for a seat at the General Meeting, and 2s. for the evening lecture, with all the advantages the Institution afforded. It would be in the interest of the Institution, as well as of the members, if the annual subscription could be reduced, so as to prevent the Institution from being split up into sections. There seemed to be no reason why, at this time, any limitations should be introduced, or any restrictions be imposed, either by rules or regulations, which might operate to render less comprehensive and complete the perfect embodiment of the profession in the Institution; and that in view efforts should be directed to consolidate all branches under one corporation, and thus to identify the power, influence, and importance of the profession at large.

There had been twenty-four ordinary general meetings during the past session, when twelve papers only, out of those submitted to the council, had been read, owing to the protracted and animated discussions to which they gave rise. Of these communications one-half had reference distinctly to foreign enterprises or discoveries, including—a description of Gifford's inventor, probably one of the most ingenious and scientific pieces of mechanism of modern times; an account of the Docks and Wharves at Manchester, and the great postal improvements there; and a description of the Chai-Air bridge, on the Madras Railway, and particularly as to the methods employed for raising the water out of the foundations; an account of the Drainage of Paris; and two Essays on the Decay of Materials in Tropical Climates, and the methods employed for arresting and preventing it. At home, the works for the Main Drainage of London and for the interception of the sewage from the River Thames, were for the most part illustrated; and the same was also the case with the Grimsby (Royal) Docks, with a minute account of the enclosed land, entrance locks, dock walls, &c.; the particulars were recorded of a highly interesting experiment—the employment of locomotive engines, for pumping the water out of the Embankment works at the mouth of the Thames, and by which it was sought to be maintained that uniform stress was perfectly consistent with the utmost economy of materials; and a description of the river Tees, and of the works upon it connected with the navigation.

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

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

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

The tabular statement of the transfers, elections, deaths, resignations, and resignations, showed that the number of elections had been 140, of resignations 5, and of erasures 8, leaving an effective number of 106, and a total number of members of all classes on the books on the 30th of November last, 1325, an increase of nearly 9 per cent. on the present number in the past twelve months.

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

An examination of the statement of receipts and expenditure showed that, during the year ending the 30th of November last, the receipts from subscriptions and fees alone amounted to £2565, as against during the same period of all kinds of £3755; while the increase was further increased by the dividends upon trust funds amounting to £253, and upon other investments (not being in trust) of £400, as well as by miscellaneous receipts to the extent of £350. Twelve years ago, in the council minutes, for the session 1853-4, it was estimated that the income was £1029, and the expenses exclusive of the minutes, to £1649. In the interval the receipts had been increased from subscriptions and fees more than two-fold, and from dividends and other sources more than seven times; on the other hand, the disbursements, exclusive also of the minutes, had in the last year been £2086 only, against the estimated sum of £1649 at the former period. The realised property of the Institution now comprised—I. General Funds, £5095 0s. 8d.; II. Trust Funds, £254 0s. 6d.; III. Trust Funds, £1979 2s. 7d., making a total of £72,982 18s. 6d. as against £26,641 5s. 6d. at the date of the last report.

The Benevolent Fund established in connection with the Institution, twelve months ago, had since been fully organised, and a committee of management appointed, who would in due course have to report to the subscribers of the fund. It might, however, be stated, that the donations actually received had amounted to £22,792 17s., and the annual subscriptions for 1865 to £712 16s., being in the former case a little in excess of the sum promised at the time, and in the latter the increase of 30 per cent.

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


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

The following gentlemen were elected to fill the several offices on the Council for the ensuing year:—John Fowler, president; Joseph Cubitt, Charles H. Gill, James Gregory, Thomas Gurney, John Hare, Honorary vice-presidents; James Abernethy, William Henry Barlow, John Frederic Bateman, Nathaniel Beardsmore, James Bruce, Thomas Elliot Harrison, George Willoughby Hems, John Murray, George Robert Stephenson, and William Vignoles, members; and Joseph Freeman and John Keil, M.P., associates.
ON THE PROPOSED NEW COURTS OF LAW.*
By Thomas Webster, Q.C.

Situation and Area of Site.
Within the district bounded on the north by Carey-street and Lincoln's-inn, on the east by the Strand and the Temples on the east by Bell-yard and Temple-bar, and on the west by Newman and Clement's-inn, is the site on which the Palace of Justice is to be erected, and the Courts and Offices of Judicature are to be concentrated. Its clearance will be commenced forthwith.

The approaches and appropriation of the site are the questions in which the public and the proprietors are most interested.

The site, when cleared, will be found to be about 20 feet higher on the north, or Carey-street, than on the south, or Strand side, and to have a gradual inclination from the north-east, at the corner of Bell-yard, towards the south-west, at the church of St. Clement Danes,—a circumstance not to be disregarded in considering the approaches to the palace, as it is from the south-west side alone that we must look for an approach terminating in the Palace of Justice, and presenting a coup d'oeil worthy of the subject.

It is too much to hope and expect that this opportunity may not be lost, but that the fullest advantage may be taken of it,—that the noble example of the Emperor of the French may be followed; that, while the citizens of Paris, in seeing their principal buildings placed at the end of newly created and imposing thoroughfares, the citizens of London may not be denied a similar satisfaction.

The approaches from the north and north-east, though capable of great improvement, cannot be adapted to an approach of the kind suggested, without an interference with a property already exclusively devoted to the profession, and extremely valuable; as, for instance, Lincoln's-inn, the New Record Office, and Rolls House; Serjeant's-inn, the Law Institution, and other buildings in Chancery-lane. A good access to the Palace of Justice from the level of Chancery-lane for carriages, and over and under Chancery-lane for passengers, may be obtained; but a grand approach, such as may be presented on the north-west, is peculiarly impracticable on the north-east side; and its attainment would render the site a great thoroughfare for traffic having no occasion to resort to the Palace of Justice.

The difference of 20 feet in the levels of the ground between the north and south may be the advantage of affording an extra floor on the southern portion of the site, and a saving of 20 feet in the ascent to the principal story—the floor of the Great Hall of the Palace of Justice—from the northern and western side.

Level of the Site and of the Thames Embankment.
The relative levels of the site and of the Thames Embankment present advantages not to be disregarded. The Strand at St. Clement's may be taken to be about 30 feet above the level of the roadway of the Thames Embankment, below which, at the depth of about 10 feet, the Metropolitan Railway and the Low-level Northern sewer.

Subways Under the Strand, Fleet-Street, and Holborn.

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

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

The ground-floor of the Palace, or that on the level of Fleet-street at Temple-bar, would be about 20 feet below the level of Carey-street; and assigning 20 feet for the height of the rooms on the ground-floor, and 20 feet above, we arrive at the level of the floor of the Great Hall, about 40 feet above Fleet-street, and 30 feet above Carey-street.

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

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

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

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

The courts, and offices immediately connected with the courts, as the retiring-rooms of the judges and the jury, will be arranged in the space between the first and second circles, each court with the offices immediately connected with it presenting substantially the arrangement of the Assize Court, but more to meet the requirements of the business to which it is devoted. The interval between each court, or each set of courts, will be available for access between the Great Hall and the great corridor, by rising, as in the courts at Manchester, to a level above the level of the floor of the Great Hall. This elevation, of any 4 feet, will give the means of access to the bench and the retiring-rooms of the judge, and to the jury box and retiring-rooms for the jury, while a descent of 4 feet will give access to parties and witnesses engaged in the cause, and afford the means of separating the witnesses on either side from each other, in convenient waiting-rooms immediately accessible to the court. This level of the floor of the
judges' rooms, which may be conveniently designated the level of the bench, forms a most important feature in the new courts at Manchester, and in the arrangements hereafter mentioned, especially in connection with the arrangement of the great hall and the retiring-room. The indiscriminate manner in which the witnesses on either side are permitted to intermix, during the progress of the case, with each other and the general public, and the difficulty with which they are introduced into, and withdrawn from, the witness-box, are serious defects in our administration of justice; and any scheme for the great hall and the retiring-room would be most seriously defective. It is of the greatest importance also that the jury should be provided with accommodation wholly independent of the door to the public, and that their retiring-room should be convenient for communication with the judge.

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

**INTERNAL ARRANGEMENT OF THE COURTS.**

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

To the relative position of the judge, with a jury-box on either side of the court, arranged with three seats holding four each, and of the counsel, no exception can be taken. The great defect is in the position of the witness-box, and the difficulty of ingress and egress for the witnesses, professional men, and others necessary for the progress of the cause. Accommodation for jury-men in waiting, for students, for short-hand writers, and reporters, must form an essential part of the arrangement. The witness under examination naturally turns to the counsel by whom he is examined; the reply to the question will be naturally addressed to the same counsel. The arrangement therefore, according to the arrangements adopted in many of the courts, from the judge and jury, by both of whom the witness should be heard and seen. The witness, if placed near to, and a little below and on the right hand of the judge (assuming the judge to be on the left of the judge), that is, on the opposite side of the judge from the jury, will speak across the judge, be seen by the jury, and heard equally by the jury and examining counsel; from whom he will be about equally distant.

The position of the witness-box in the Courts of Queen's Bench, Common Pleas, and Exchequer, is an illustration of this; but the witness might with advantage be nearer the judge than in any of those courts. In other courts, in the county of London, the witness is usually turned on one or the other, and he will sometimes get engaged in conversation with some of the jury, a most objectionable and inconvenient practice. None of these courts present convenient or isolated ingress or egress for the witness, who must struggle and be internecinized with the general public, and be involved in the general bustle both before and after his examination. Nor are the jurors, counsel, attorneys, or parties any better off, as the experience of those attending the courts at Westminster, and other courts in the Metropolis, will affirm.

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

**LIMES, CEMENTS, MORTARS, AND CONCRETES.**

By Chas. H. Haswell, Engineer, N.Y.

(Continued from page 257, vol. 23.)

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

Mortar.—Lime, 1; clean sharp sand, 2½. An excess of water in slaking the lime swells the mortar, which remains light and porous, or shrinks in drying; an excess of sand destroys the cohesive properties of the mass. It is indispensable that the sand should be sharp and clean.

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

Exterior Plaster or Stucco—1. volume of cement powder to 2 volumes of dry sand. In India, to the water for mixing the plaster is added 1 lb. of sugar, or molasses, to 8 imperial gallons of water, for the first coat, and for the second or finishing, 1 lb. sugar to 2 gallons water. Powdered slaked lime and smiths' forge scales, mixed with blood in suitable proportions, make a moderate hydraulic mortar, which adheres well to masonry previously coated with boiled oil. The plaster should be applied in two coats laid on in one operation, the first coat being thinner than the second. The first coat is applied upon the first, whilst the latter is yet set. The two coats should form one of about ¾ inch in thickness, and be finished in 2 or 3 days.

This process may be modified by substituting for the first coat a wash of thick cream of pure cement applied with a stiff brush just before the plaster is laid on. When the cement is of too dark a colour for the required shade, it may be mixed with white sand in whole or in part, or lime paste may be added until its volume equails that of the cement paste.

Khurasan, or Turkish Mortar, used for the construction of buildings requiring great solidity, Produced powdered brick and tiles, 5 fine sifted lime. Mix with water to the required consistency, and lay on layers of 6 and 8 inches in thickness between the courses of brick or stone.

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

Coarse Stuff.—Common lime mortar, as made for brick masonry, with a small quantity of hair; or by volumes, lime paste (30 lb. lime) 1 part, sand 2 to 3 parts, tartar, 5. Part when full time for hardening cannot be allowed, substitute from 15 to 20 per cent.

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

Fine Stuff (lime putty).—Lime slaked to a paste with a moderate quantity of water, afterwards diluted to the consistency of cream, and then allowed to harden by evaporation to the required consistency for working. In this state it is used for a "slipped coat," and when mixed with sand or plaster of Paris it is used for the "finishing coat." Gauged Stuff, or hard finish, is composed of from 3 to 4 volumes fine stuff and 1 volume plaster of Paris, in proportions regulated by the degree of rapidity required in hardening; for cornices, &c., the proportions are equal volumes of each, fine stuff and plaster.

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

Scratch Coat.—The first of three coats when laid upon laths, and is from \( \frac{1}{2} \) to \( \frac{3}{4} \) in. thick in masses.

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

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

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

Slipped Coat is the smoothing off of a brown coat with a small quantity of lime putty, mixed with 5 per cent. of white sand, so as to make a comparatively even surface. This finish answers when the surface is to be finished in distemper, or paper-hangings.

Hard Finish.—Fine stuff applied with a trowel to the depth of about 1/6th of an inch.

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

<table>
<thead>
<tr>
<th>Materials</th>
<th>Three Costs Hard-finished work</th>
<th>Two Costs Slipped work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime</td>
<td>4 caasks $4.00</td>
<td>3½ caasks $3.33</td>
</tr>
<tr>
<td>Lumps of fine stuff</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Plaster of Paris</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Laths</td>
<td>2000 4.00</td>
<td>2000 4.00</td>
</tr>
<tr>
<td>Hair</td>
<td>4 bushes 80</td>
<td>3 bushes 60</td>
</tr>
<tr>
<td>Common sand</td>
<td>7 loads 2.00</td>
<td>6 loads 1.80</td>
</tr>
<tr>
<td>White</td>
<td>22 bushels 22</td>
<td>22 bushels 22</td>
</tr>
<tr>
<td>Nails</td>
<td>13 pounds 90</td>
<td>13 pounds 90</td>
</tr>
<tr>
<td>Masons' labour</td>
<td>4 days 7.00</td>
<td>34 days 6.12</td>
</tr>
<tr>
<td>Labourer</td>
<td>3</td>
<td>3.00</td>
</tr>
<tr>
<td>Cartage</td>
<td>0</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Cost of 100 yards  $25.50  $19.95

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

Hydraulic.—\( \frac{1}{2} \) part hydraulic lime measured when unslacked, \( \frac{1}{2} \) part sand, \( \frac{1}{2} \) part gravel, 2 parts of a hard limestone broken. This mixture is 1 in volume. Full lime may be mixed with concrete, without serious prejudice to its hydraulic energy.

Various Compositions of Concrete.—Forty Richmond and Tompkins, U.S.—Hydraulic—308 lb. cement=3.65 to 37 cubic feet of stiff paste. 12 cubic feet of loose sand=9.75 cubic feet of dense.

For Superstructure.—1175 cubic feet of mortar as above, and 16 cubic feet of stone fragments. In the foundations of Fort Tompkins, about one-twelfth of its volume was composed of stones from \( \frac{1}{2} \) to \( \frac{3}{4} \) of a cubic foot in volume, rammed into the wall as the concrete was laid.

Sea Wall.—Boston Harbour.—Hydraulic.—308 lb. cement, 8 cubic feet of sand, and 30 cubic feet of gravel. The whole producing 32.3 cubic feet.

Superstructure.—308 lb. cement, 80 lb. lime, and 146 cubic feet dense sand. The whole producing 12.8 cubic feet.

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

<table>
<thead>
<tr>
<th>Labour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wages of bricklayer, mason, plasterers, &amp;c., $2 per day</td>
</tr>
<tr>
<td>Masons setting planks and flooring at $2 per day</td>
</tr>
<tr>
<td>Labourers and plasterers</td>
</tr>
<tr>
<td>Total cost of labour</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>4096 caasks of cement at 85 cents</td>
</tr>
<tr>
<td>12288 &quot; sand at 5 cents</td>
</tr>
<tr>
<td>20,490 &quot; broken stone at 8 cents</td>
</tr>
<tr>
<td>Total cost of labour and materials</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Masonry</th>
<th>Cost of Mortar</th>
<th>Line required, or cement, required, or both</th>
<th>Cost of Mortar.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rough, in rubble or gravel, from ( \frac{1}{2} ) to ( \frac{7}{8} ) cubic foot in volume, blocks, large and small, not in courses, jointed hammer-dressed</td>
<td>$0.10</td>
<td>$5.65</td>
<td>1.22</td>
</tr>
<tr>
<td>Large masses; headers and stretchers dovetailed; hammer dressed; bed and joints laid close</td>
<td>8.1</td>
<td>4.23</td>
<td>9.2</td>
</tr>
<tr>
<td>Ordinary; courses 20 to 32 in size</td>
<td>1.5</td>
<td>0.98</td>
<td>1.7</td>
</tr>
<tr>
<td>Ordinary; courses 12 to 20 in size</td>
<td>2</td>
<td>1.05</td>
<td>2.2</td>
</tr>
<tr>
<td>Brick, large and small</td>
<td>8</td>
<td>4.2</td>
<td>9.0</td>
</tr>
<tr>
<td>Concrete, good</td>
<td>11</td>
<td>5.4</td>
<td>1.75</td>
</tr>
<tr>
<td>&quot; medium</td>
<td>11</td>
<td>4.1</td>
<td>1.05</td>
</tr>
<tr>
<td>&quot; inferior</td>
<td>8</td>
<td>3.7</td>
<td>0.97</td>
</tr>
<tr>
<td>Rubble, without mortar</td>
<td>3 to 3.3</td>
<td>$c t$</td>
<td>$c t$</td>
</tr>
</tbody>
</table>

Cost of materials assumed as follows: Cement, $1.20 per barrel; line, $1; bricks, $4.25 per m.; sand and gravel, 80 cents per ton; granite spalls, 5 cents per cubic yard; labour, $1 per day. For walls less than 2 feet in thickness the cost is increased.

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

By T. Seymour Burt, F.R.S.

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

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

But there is another argument against the use of one ship only. That ship must, like the Great Eastern, necessarily be of immense size, in order to be sufficiently capacious to contain, or stow away, the whole main length of cable, which consists of 1800 or 2000 miles of the greatest part of the ATLAS! the stress exerted upon the cable when she raises her bow above the surface of the water—like as a giant pulls more strongly than a child. A smaller ship's hull or strain exerted upon the over hugging cable would not so tend to rust that cable (notwithstanding its tendency to rise to the wave to a greater height than the bow of the larger ship) as would the terrible dead weight and rise or stress or strain of the huge ship itself, the resistance of the cable being necessarily overwhelmed by the superior momentum of the latter vessel, and being thereby caused to be rent in twain, from the effect of the increased tension, which serves to break it like a piece of thread. And therefore, probably if a very slight strain could be measured at all upon the Great Eastern, on her next attempt, and could then be made to receive the descending part of the cable after it has left the latter ship, and, next, to deposit it directly over its own bow into the deep, the cable would be less liable to be torn the same, nor is it likely that the ship should pay it out alone and at once over its own bow directly into the abyss.

But why did the cable which had been first laid fail? A reply to this momentous question is printed in Part I., Vol. III., of my Miscellaneous Papers on Scientific Subjects, London, 1861, pp. 32-5, in a letter addressed to the late Viscount Palmerston, which was dated July 2nd, 1863.

I repeat the question. Why did the first-laid cable fail, after having been properly laid from end to end? It failed simply because one-half of the length had been twisted (in manufacture) to the right hand of the line of its axis, whilst the other half had been twisted to the left hand of the same line or axis. How was this done? No one knew, as the cables were so prepared at the banks of the Thames, the other half in another locality, the name of which I forget. Yet, strange to say, this fatal defect was considered, it appears by the Times of the 13th of May, 1858, to have been remedied or "overcome" by joining the the two ends, in midway Atlantic, to certain "rods of iron, loaded with a weight in the middle of the cable"; but it was so hasty a cure that it was not generally believed—would rectify the fault. And so the cable failed—and, yet not even a trial beforehand was made of the two pieces—pieces contrarily twisted, be it remarked, and known to be—so by joining them together, I mean the half cable twisted, to the right hand and the other half twisted to the left, in order to ascertain the effect of a heavy strain exerted upon those two halves when so joined. The consequence was that the so-joined coils, each consisting of one-half the whole cable, soon began to separate from each other, and finally, instead of passing through the gradually attenuated core or copper wire, upon which the entire strain or stress was now thrown, became weaker and weaker, until they shortly afterwards, like my Uncle Toby's pulse in "Tristram Shandy," fluttered, stopped, but again, as if entirely ceased. Nor was this effect to be wondered at. Let any person of average common sense try the effect himself with two sets of small wires (or threads), three or four threads in each wire; one set twisted to the right hand the other set to the left hand of the axis of each coil, and then let him, after having joined one end of one coil to one end of another coil, and then twisted them together, after having stretched the whole coil in a straight line, with a stress bearing upon it, state from his own experiment, proof, and experience, what he considers to have been the main, if not sole, cause of failure of the first-laid Atlantic Telegraph Cable.

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

The point now, however, for consideration is, how to lay the cable again after the occurrence of two not altogether unexpected failures; or, rather, how to lay a new cable, and that, if possible, without having to "haul in" again any portion of it after it has been "paid out," in order to discover the whereabouts of its faulty insulation, and with a certainty of weakening the chain or cable on every occasion that it is cut and again spliced. Now, this difficulty may be partially obviated by not laying the cable horizontally across the ocean, but letting it be carried in one of the tugs. Therefore, I assume it must be evident that the greater the number of splicings or junctions in the same the less the chances of its efficiency. The parts "spliced" together cannot possibly be so strong or so closely connected, or the central wire (the vehicle of the electric message) so intimately adhesive in all its fibres, as the one originally manufactured in its integrity. What a large number of splicings or junctions there must have been in the late Atlantic cable! first, there was the batch of splicings required to join each of the several lengths sent down at different periods from Messrs. Bliss and Elliott's workshops by each vessel that shipped a portion of the cable, say every 500 miles; the tugs, carrying the cable from the Irish shore to the Great Eastern. Then a splicing was required for each of the tugs when filled, or at any rate for two out of the three tugs in which the cable was stowed on board the Leviathan ship. Next, the "splicing the main brace" to the end at the Irish shore, and "yet another" splice would have been required at the junction with the tugs. But I cannot see no more," as Macbeth says, almost dreading this long account of splicings in the late cable, and trusting it may be possible to avoid some of them in the new one. The first laid cable was not so cut and so joined, it is to be presumed, as the second one, and yet the former was undoubtedly laid the whole distance, and for the whole of its length, with a single splice. It must be seen from end to end—from America to England, and without the occurrence, that I am aware, of any breakage or separation of the coil (save one), in consequence of a mishap. How was this done? By the employment of two ships. And would not the cable
have continued its insolation for a reasonable time—not expecting, of course, that it would have solved the problem of perpetual motion—had not its two halves been coiled, unfortunately in two contrary directions; and had they not still more unfortunately been joined together with that soul and fatal fault existing; although the fact was known at the time, or beforehand, certain at the vernacular of May 5th, 1855, without a trial being made to ascertain whether it would, when completed, succeed or not, and when such a trial would have caused but a few hours’ delay in the commencement of so great and glorious an undertaking.

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

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

STUDY AS A PREPARATION FOR PRACTICE.*

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

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

At the outset I must apologise if I appear to assume a dogmatist's tone. If this is so, I must plead as my excuse that you will hear but little-to-nothing except things of the truth and importance of which I am very forcibly convinced in my own mind; yet in pressing my views on your attention I desire to refrain from seeming to do so with that positiveness which he might well assume who was conscious of having as a student done all that I recommend you to do, and been all which I desire each of you to become. If parts of this paper are written with a consciousness of advantages gained, other parts I write that you should escape mistakes and supply omissions of which the speaker is keenly sensible; and throughout I hope that your own judgment and good sense, and the experience of those best able to advise you, will be brought to bear upon the suggestions made to you.

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

As an example, I may just point out that with regard to most of you there is nothing so likely to be useful as something which will induce you to work far harder than you do; yet there can be no doubt some few of you are already working too hard, and that every additional spur to you is an injury. Again, in the case of a large part of you, I might, no doubt, do more good by simply and solely urging you to draw more, and draw better than you do, than I could by anything else. But there are sure to be some of you to whom any other work than drawing is distasteful, and who would lose nothing by a little drawing. Still, I think that drawing is an essential part of the practice of any profession, and that it is a profession which is generally not so well understood as it might be, and not so well named as it perhaps should be. This is a profession which is generally not so well understood as it might be, and not so well named as it perhaps should be. This profession is one which is generally not so well understood as it might be, and not so well named as it perhaps should be. This profession is one which is generally not so well understood as it might be, and not so well named as it perhaps should be.

* Paper read at the Architectural Association.
pointing out what is, in my opinion, desirable before a pupil enters an office.

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

If his name should be well-bred, that is to say, not honest and brave, gentle and courteous, he will find the general conduct of his profession beset with infinite difficulty, and will bring discredit upon his calling. If he want application and tenacity of purpose, the large amount that there is to learn, and the great deal there is to do, and the serious difficulties there are likely to be, will overpower him. If he be a wise and deep-seated student, who has been well and deeply instructed, and if he be so, history, the mathematics, and modern languages, which are all technically desirable, almost essential for him, will be among his acquisitions.

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

The absence of anything like an artistic education from our public schools and colleges is no doubt a main reason why architects as a profession have fewer attractions for university men than other callings. But there may be other reasons. The entrance to practice is not guarded yet, though the time is coming when it will be, by an official examination; its highest prizes are nothing approaching what are obtained at the bar; and perhaps our average incomes are not so high as to render the number of Oxbridge and Cambridge men in our profession so small as yet. At present, at any rate, the possession of a degree is a distinction of no small lustre among us. For the bar and the medical profession an university career is considered almost an essential, yet the learning, knowledge of the world, good connections, and personal merits, are considered as advantages in a lawyer’s favour, and to the full as needful to him as to the physician or the barrister.

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

Where an university education is not attainable, a good classical, mathematical, and general education, the best possible, is most desirable, and in this no special branches of study need be insisted on. The architect must be a cultivated and instructed, and if he be so, history, the mathematics, and modern languages, which are all technically desirable, almost essential for him, will be among his acquisitions.

Of special culture, the chief, perhaps the only points to be insisted on are drawing—not architectural, but of the figure and landscape, and general culture of taste for and knowledge of the fine arts. This I should like to see carried very much further than is ordinarily attempted, before a student begins his life as an architectural pupil; and I believe that in many cases a youth who has left school in order to become an architect would gain time by devoting the whole of one year to nothing but drawing, architecture, sculpture, and music. He will not require simply to keep up his other attainments, in place of going into an office. It would not be too much to expect that a student should be able to draw the figure well from the round, well enough for example to procure admission to the Antique School of the Royal Academy; and that he should sketch well from nature in water-colours with freedom and finish; ornament, and mechanical drawing, and perhaps perspective, I think he had better not study till he begins as an architect, but in the figure and landscape, and let me add modelling, if practicable, it is hardly possible to do too much or to fix too high a standard. To this is a great part of the value of the fine arts of painting, sculpture, and music, ought to be joined; and the earlier both drawing and general art are begun the better.

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that getting accustomed to things is not what I mean by learning them. There may be some few things that one learns tolerably well by getting accustomed to them; but they are very, very few, and are none of them known intelligently. It is this in fact that I have chiefly to warn you against. At first there is such a multiplicity of unaccustomed things doing and passing before him that an office appears, to the new comer, a remarkable, often even an alarming one. But these are very few, very few, very few, and really, if you speak learned, the majority of them are simply acquiesced in, the pupil gets accustomed to them, perhaps he even bears a hand in them, and yet he never learns them; possibly, after the first blush of his curiosity has gone off, he may hear them pass, without giving much thought to them, there is still an injury in the majority of them, till years after he comes to find that he is deficient in an elementary knowledge which he might, had he so pleased, have easily picked up while in his articles.

I could give a hundred instances of this, any one of which I am sure almost all of you would admit to be true. Take an example at random—you are told to work out a staircase on a plan and section, and that the risers are to be seven inches and the treads ten; with some constraining you do it, and the drawing is approved, and you go home well contented at having learned all about staircases and how to contrive them, when in truth, for the most part, you had forgotten it the following week, or the bare notion of a riser to be seven and the tread ten? Supposing there was not room for your staircase, how could you make it steeper; supposing you wanted a broader step, what sort of a riser would be right then; or, with a steeper riser, what tread would you require? Or again, your master comes, and says there is no headway—alters the plan and text, says you must learn something more. I mean that if you are to learn, you will not rest till he tells you, or better still, till you find out what “headway” means, and what dimensions it requires. If you are merely stupidly getting accustomed to your work, you will quietly ink it in, as altered, without any intelligent understanding of what you are doing. Or unless it is an unimportant thing, and that is rare, you will be annoyed with the whole process of learning, and go home hoping something is learned which is not.

There are a dozen other points in which a staircase might illustrate what I mean, but the truth is, that not a drawing goes through a pupil’s hands, not a letter does he copy, not a letter does he endorse, hardly a message does he put down in the cell-book of the office, let me say that first, this is a junior member of the profession from it. Of course such technical things as complicated drawings will not give up all their treasures at once. A plan speaks to the veteran in a language in which the tyro is but picking up the letters and the spelling, but where all is so full of novelty, every person truly desires to learn, whatever may be the degree of his acquirements. But it is a slip to end the day no wiser than he was at the commencement.

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

I would suggest that you regard the office as your school, and your master an examiner, and desiring really to benefit by the opportunities it offers to him, that he shirk no part of the work. Some young gentlemen, because a premium was paid with them and they think themselves “swells,” will not strain a sheet of paper, or print a drawing, and will barely speak to a stranger. Of these, and all other duties of this sort, I must say, that in my opinion, a new comer ought cheerfully to take such a share of them as falls to his lot, knowing well that if he is able to make himself properly proficient at higher things, the rudimentary work will very soon naturally drop off his back and descend to some one else. Secondly, that part of a thorough knowledge of architectural practice, is a personal acquaintance with every detail of office routine. And thirdly, that some of these are more useful than they seem, especially the seeing strangers who come on business, and putting down messages correctly. This work, which may seem a slight matter, is one of the greatest, if not the greatest, of all duties of an office. It makes good training, and often the only training that will come in your way for years in that most necessary accomplishment, the conduct of business.

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

By-and-by, little by little, the young architect will find the chaos shaping into something like order: he will begin to understand drawings, and buildings, and office work. At this stage common construction is the portion of the work which it seems to me to be especially valuable, to familiarise the attention of young men in an office, supposing they have begun to use their instruments freely; for it takes many months to master this thoroughly, I think few men who have been less than two years in an office would ink in a set of drawings and leave all the straight lines straight and firm, and all the circles round and unconfused. It will involve the ordinary routine of putting a building together, how trimmers are managed, how arches are turned, how walls are plastered, and so forth. This is all well; master it all, but let me entreat you, at as early a date as you feel yourselves getting the rudiments of office work into your heads, to aim at the highest parts of your profession. As far as possible, as much as possible, let the work rest on the simple, with the simple, as much as possible.

One difficult thing so mastered is worth, and in fact will teach, many minor matters.

Make it a rule, however, that whatever construction enters into your drawings done in the office you well understand it all, and not just how to make it copies. This will involve the giving in detail of that sort of knowledge which is so necessary in certain circumstances. The technical art in that office. You will find that even in a large and complicated office you will have to know a great deal about the way the work is done, and there is a great deal of trouble of fellow-clerks, or pupils, and much here and there introduce delay into things which you might wish otherwise to hurry; but be obstinate if necessary, both with yourself and others, on this point, for without it the habit of shirking difficulties instead of mastering them will be formed, your work will slip, and instead of thorough, and your progress will be apparently rapid, yet in truth not real.

And by-and-by some little work is entrusted to you to work out the drawings, and draft a specification. I mean to say that the principal’s eye, let none pains be spared, no effort omitted, to make your work as good as it can be, and especially in as good taste.

Even art-work however, must not occupy all your time in an office. Perhaps you are sent away in the car, to get you all the business that can be got, in the city, or at least to trace, as you can secure. Do all the detail drawings anyone will let you do, and strain every nerve to do them well. If by-and-by some little work is given you to work out the drawings, and draft a specification, never mind the principal’s eye, let none pains be spared, no effort omitted, to make your work as good as it can be, and especially in as good taste.

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in progress. If there is a good building, in fact, if there is any building being done by the architect whom you are with, with reach of the office, go to it for a while, and see what you can, and think of all eyes and ears when you are there. Make friends of the clerk of the works, the builder's foreman, and some of the artificers of every trade, and ask all manner of questions, make all manner of investigations, remember all you can, sketch all the construction you see, and put down in a memorandum book all the principal matters you learn. With a relative eye to the effect of any details, the drawings for which you may be familiar with in the office, as they are worked on the ground, and again as they are fixed in place. Get a notion of actual size — that is, to say, try to understand what a foot in height or a foot in projection will look like. There is a way of finding out which is a good way. If you feel up to it, if you can, try to imagine how you can, and try to imagine how you would feel if you could know the building as an artistic work from beginning to end. Learn it as a structure, find out which is good and which bad of the materials. Coax the mason to show you which is the bed-way of the stone, and the bricklayer how to bond each thickness of wall; watch the mixing the mortar, the throwing in the concrete; and, when you have learned these things, you will have something you want to do, to make a friend of your master in the office.

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

Thus much for office life in its earlier stages. Pupils are now mostly on short terms, such as three or four years. I have never been under such a master, but I feel sure that he will be a good one, as he generally has an opportunity of doing if he likes, a year or two in the same office with advantage after the expiry of such a term; but it will be of great advantage after from four to six, or at most seven years, to change, and spend a little time in each of two or three other good offices, so as to become accustomed to different ways of doing things, and to see different styles of work, before attempting to practice.

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

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

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

The next matter to be attended to is the desirability of obtaining a good systematic acquaintance with the history and the general forms of past styles of architecture, and the theory and practice of construction. Fortunately, we may benefit in the many years in London excellent courses of lectures on these subjects from a most learned and accomplished professor, whose perfect knowledge of his subject was only equalled by his ability to teach it — need I name Prof. Donaldson? and no less fortunately is it that, now that he has withdrawn from the chair, we have the best successor for the benefit of the whole profession has succeeded to it. All students should attend Prof. Hayter Lewis's courses of Lectures at London University College. To these they will require to devote two evenings a week for the winter months of two years, and no inconsiderable additional portion of leisure besides. These lectures will be most advantageously attended after one or more years have passed in an office, and should hardli
I think, be commenced quite at the beginning of pupillage. Another course of lectures, on the Arts of Construction, is also delivered annually, at King's College. Of the ability of my professor, our well-known friend, Prof. Kerr, I need not say a word; and I should heartily recommend that these be also attended. In the days of Prof. Foskitt it was generally supposed that this course was not intended for architectural pupils, so much as for those who were to be military or civil engineers, but I feel assured that the profession, now the course will be of advantage to any or all of us who can attend.

At this Association students will find opportunities of self-improvement, such as will be of essential service. The most important features to men of two or three, or four years' standing will be, I take it, our old established Class of Design, with perhaps our more recent Voluntary Examination Class and the Life-School. The meetings and papers will also become thoroughly interesting, the better they are known, though many of them will from the first be liked. But the Class of Design is the institution that I most cordially recommend the young pupil to enter as soon as he has got a smattering of the rudiments of his art. It will do much to introduce the use of an excellent library; and the young pupil will fix his aims upon that artistic part of his profession which I am so anxious he should keep prominently before his mind. Our Life-class will give him an excellent opportunity of keeping up and improving his draughtsmanship; and our Voluntary Examination class will afford him the opportunity of becoming acquainted with and at least an acquaintance with many others. This class might with propriety be called the Class of Construction and Practice, as distinguished from the Class of Design; and if you will only join it in numbers sufficient when it starts next session, very shortly to commence, you will find yourself well repaid. It is one of the most important of the old Association classes, and the Natural Association, that here a student makes friends. Few are so constituted that they can do without some companionship in their work, and here many friendships have been begun which have proved of great advantage during student-life, and of permanent value through afterlife. Let me then cordially invite, and sincerely advise, all the young men to join the Class of Design, and join us without delay, if it be only for the sake of securing companionship in study.

The next public institution deserving notice is the Royal Academy. The advantages offered to students are not great, but they are by no means contemptible, and they are entirely free. They include the use of an excellent library; they still choose on architecture, when any are given, being uniformly valuable, a course of instruction in perspective, which those who have attended it speak of as excellent; admission to the exhibition of paintings; the opportunity of competing for medals, and ultimately the possibility of obtaining a travelling scholarship. The chief advantage of the young architect, I think to be the stimulus of making a design for the purpose of obtaining admission; and this I know to be so valuable, that, while I would not wish any to try whose draughtsmanship and powers of design are not sufficiently matured to give a fair chance of success (for it is always unfair to court success), I hope you will all be bold enough to be brave when it meets us fairly. I think every pupil who enters an office should make the Academy part of his programme. The period for trying will vary much with the student's proficiency; his third or fourth year ought ordinarily to see him advanced enough to command admission.

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

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

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

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

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

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

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

I believe many minds are embarrased, in the prospect of attempting so large and various a mass of acquirements, by the
apparent intricacy as much as, perhaps more than they are over-
whelmed by the amount of the work to be done. They cannot
study where to begin, and what to be at first, and they possibly
yield to a kind of despair, oppressed by a difficulty to which they
have not been accustomed. So much for books; but books, how-
though the field be very vast, the part of it actually open to a
student is but moderate. Ifso, his duty is very clearly to occupy
what lies before him; for example, suppose he has but few build-
ings available, but has access to one church of original
workmanship, and has time to make some careful studies, but
the scale is too large for him to undertake the twelfth and
thirteenth century work was the finest. What of that? Perpen-
dicular is, among the things to be known, studied, and drawn,
and if he masters it now he will be all the more at leisure to
study Early Pointed examples when he meets with them. Or as
a book, he has only a few, and they not the most modern.
Matters is not new ideas, though modern reserve I have
extended our field, it has left the bulk of what was already known
unchanged. In architecture, whether you consider history,
science, art, or material, you cannot establish in any a proper
and unchangeable sequence of things. You may either begin, if
the history for example is your study, with the practice of the
present day and our own country, and work downwards; or you may
begin the history in the middle, and work downwards, and
upwards, and sideways; or you may begin at the commencement
of all time, and follow as best you may the stream of events.
Either plan has its advantages. Similarly, you may with equal
readiness, or you may by the art by that of a foreign country and
come homeward from that starting-post, or begin at home and
spread onwards.
I think then it is sound advice to say, that if anything within
the range of your proper studies offers itself, either through your
having to possess peculiar facilities for its study or through
its presenting itself to your mind as desirable, select it and begin
by it. Knowledge grows like a snowball, from a very small
nucleus, and will gather pretty nearly as well upon any genuine
nucleus; indeed, nothing is more surprising than the way in
which, when any part of a subject is thoroughly well known,
other things range themselves before and behind it, and attach
themselves to it. For example, if you had already studied,
the opportunity of studying one ancient church. The man who has really and completely done this has
made a vast stride towards the study of the whole of English
church architecture. You cannot know the characteristic mould-
ing of one jamb or one mullion, without gaining some insight
into the whole of church architecture; and as you have gained
one, you will not be able to avoid being influenced by it.
Knowledge, as a snowball, is not to be caught, but to be
made. If you cannot become familiar with those points which are
especially marked of date, without learning something of how what preceded
and what followed was treated; and you could not understand
one bay of a vault or one tracery window without finding that
you had gone through the worst part of the difficulty of studying any
architecture. The correct appreciation of the various
forms and what to begin with, remember that to begin with what is most
within reach is, ordinarily not only easiest but wisest.
There may however be those who, having fairly the opportu-
nity of selection—a good library available, a good set of photographs
or casts or engravings at command, or in some other way a
mean for choice at hand—cannot exactly be said to have only
one thing offering itself to their notice more prominently than
another, and are forced to make a selection and to form some-
thing of a plan of study for themselves. In this case it is
hardly admit of doubt that the wisest thing is to begin with some
port of art, and not the best part of the whole of art. Always
put the art first, and let even the most important aspect of
the history of architecture, be subsidiary to the knowledge of the
actual artistic and structural forms, and the power of drawing
them, and of designing and grouping similar forms. But where
in the large extent of varied periods and styles of architecture
about which the art is big and the book a kind of art, the kind
of the architecture of one of the best periods; if one can be found
free from great complication and extreme elaboration. As there-
fore the earliest phase of Christian art in Europe unites all
these characteristics, and is moreover, pretty fully illustrated
in the best hand books, especially the French ones, and in many
photographs and engravings of buildings now begun, by
making yourself familiar with the forms and general aspect of
what is termed Romanesque architecture. This architecture,
especially the French variety of it, is very beautiful, yet very sim-
ple; ascending from it you go back in a clear course to the art of
Rome, Greece, Egypt; and descending you come down through
all the varied styles of Christian art to the present day. Study
it chiefly with the pencil, and as far as you can from existing
examples and plaster casts, when these fail, from photographs,
engravings, and books; you will find English Norman, and how far it differed from the contemporary and
earlier work of France and of Italy, and have drawn some of the
most interesting features, such as doors, west fronts, cloisters,
you will find an inexhaustible mine of wealth in the enrichments,
especially the capitals, of which good casts are very easily obtain-
able and useful, and really he who has studied the
Norman, and the Romanesque, and master the Romanesque work of Europe, from the
classical churches of Rome or Ravenna to the transition of
Norman into Early English, that you will not need any further
advice as to progress so far as the later styles are concerned.
In picking out your examples from the various books you will
have learnt half of what there is to tell as to the later develop-
ments of Christian art, and your course downwards will be easy
enough.
I should like however strongly urge to desire the desirability of going
backward as well as downward, and learning what was that
Roman architecture from which sprang the Romanesque, and
learning to understand the Romanesque as well as to
criticize it, the Greek art from which sprang most of whatever we have that is
good. Study also the development of Roman into Renaissance,
and learn to know something of the meaning of an "order," a
"module," and the other formulae of the Italian masters, and
think equally whether you have entire sympathy with it or not.
It is disgraceful for a pupil of the present day to decide against
a school of art to know just nothing about it.
The leading study of all these things should be drawing then,
trying to draw things like them of your own design, and reading
and making notes about them, but mostly drawing. Notice how
they were put together (Construction), as well as how they were
shaped and combined to satisfy the eye (or design). Early
commence to try making designs, and if you adopt my advice, and
begin your study of architectural forms with the art of one period,
as for example French Romanesque, and confine your study for
many weeks or months to that, you will of course during the same
time and to see to whether you also take in the same style.
I think the arrangement and mode of constructing our Class of
Design, makes it a capital opportunity for a young man of cul-
tivating the very necessary art of designing. I believe it quite
worth any student's while to join the Association for this class
only, and I very strongly urge it upon the attention of you all;
adding to my heartfelt recommendations that you shall try it, the
one caution that you should in working out its subjects embrace
every opportunity of showing the plans and some of the details
as well as the general outline of your design, not containing yourselves with a showy sketch, but working it more or less as
though the drawing were to be built from.
There is no objection for a loss of the prizes offered by this Associa-
tion, the Institute, and the Royal Academy, will from time
to time offer you opportunities of trying your strength with the
advantage of a stimulus to your exertions in the shape of a prize.
I cordially recommend you to try them, and when more advanced
believe you will find it, as I said more at length in my paper
"On Earring Practice," a highly advantageous mode of study to
compete for actual buildings. All these competitions give you an
opportunity of exercising yourself in the arrangement and
adaptation of your building to its requirements and intended
uses, an art not to be picked up just at once, but requiring to be
acquired by repeated experience. Whether you have advised you to proceed in learning the elements of
architecture as a fine art, I would advise you to some extent
to learn it as a constructive art. If from any accidental
circumstance any special material or any special branch of
construction offers itself to your notice or attracts your attention,
better, even to be heeding it, until you have a kind of an idea
occurs there, take one branch and master its elements, and
afterwards take up another. I am inclined to recommend
carpentry as a good branch to begin with, next bricklaying
and masonry, then joinery, and then iron construction. But
you ought, as far at least as the rudiments go, to be learning the
groundwork, as you may say, and then to go on, and if you
ought, pretty much at the same time, from your office work and
your visits to buildings; and I do not think you can go wrong in
considering all these arts under the general head of construction,
and regarding them as one study, so far as your ordinary office
and building observation (taking Dobson's Art of Building as your hand-book) will carry you. This must be going on at the same time as the rudimentary study of the art, and the cultivation of draughtsmanship. The subsequent systematic pursuit of the less elementary portions of the different constructive arts which I have named, takes up one by one, ought to go on at the same time as the particular art may be designed. Scott's, or any of those other works must be thoroughly studied. Before we can advance at all in architecture as a fine art, we require to know at least something of building as a technical art, and before we advance far, we require to know much of it, for all true architectural art is the out-growth of sound construction, and stands to it in the same relation that poetry does to the list of subjects, of which we thus far, under the name of constructive geometry, and though the simpler features and forms of architecture, such as doors, windows, columns, and arches, can be understood and mastered without any profound constructive knowledge; the case is different as you go on and begin to learn, or to try to design entire buildings, or the more complicated parts of them, such as vaults and roofs. You will find that you require to understand these before you can observe, measure, or draw them with advantage; and above all, before you can design them so that they look well, or would be likely not to fall down if they were built.

This is how to conduct your studies. Each year of your studies will be very much advanced if you spend some time at the joiners' bench or the masons' bank, or if you take the post of clerk of works on a building. The objection to entering a workshop, unless you may take all about the place you are going to, is that you are liable to hear bad language and see bad conduct. This risk is run everywhere to some extent. It is true, I have been in a great number of the shops more exposed to it than necessary; so that special care should be taken to know what the habits of the men are among whom a youth is placed before he be sent into a workshop, but I believe it to be most beneficial, and to promote a more thorough knowledge of the minutiae of construction than any other portion of education. It is a thing with your own hands, you can hardly fail to understand it.

Employment as a clerk of works would be, I think, readily obtained by most skilful well-trained office hands of some years' standing if it were sought. The duties afford an admirable opportunity of learning both how a building is constructed from first to last. They are interesting and helpful, and give you a great deal of information. Every week point in the plans and specifications becomes known to the clerk of works—every unexpected occurrence of whatever nature on the works comes under his notice; and if any of you on my recommendation or otherwise get a twelvemonth's occupation as a clerk of works on a good building, I will engage to say that at the end of the time you would feel as little profit and as little leisure as if you had never learned so much in the same space of time before. I may also fairly say that, if such engagements are useful to yourselves, I should fully expect them to prove on the whole useful not only to you, but to your employers than the employment of average clerks of works, judging, however, not by the merits of the persons, but of their office, of the 20th of May.

After the two broad and very comprehensive subjects of the leading forms (and principles of composition) of the main European styles of architecture, or most of them, and of materials and construction, there come a large number of other subjects, of which it is desirable to know some; but of which few, if any, know all. I am not now going even to attempt a comprehensive enumeration of them. You will find most of them enumerated or referred to in the Institute programme of examination and list of books; and as a general rule, I may say broadly that any knowledge you can get on any of these subjects is desirable; and that you are much to your advantage by learning the historical and architectural aspects of the subject. Of the indispensable subjects, I may briefly enumerate warming and ventilation, drainage, and some outline of the laws relating to contracts and to buildings. As examples of less essential though most highly desirable acquirements, I may cite mineralogy, geology, chemistry, the laws of light and sound, heraldry, botany, &c. As examples of the other studies or arts bearing on the fine art part of the profession, I might name as essential the principles and something of the practice of decorative colouring, and the chronology of architecture, which is indeed the history in minute detail, and which, as far as English Architecture is concerned, you will learn best by gaining a very intimate acquaintance with all the details and all the dates of a few good buildings extending over a long period of time. Other acquirements are the art of modelling or carving, special acquaintance with stained glass, metal work, jewelers' work, enamel work, mosaic and other inlaid work, landscape gardening, etching, lithography, antiquarian research, and such special branches of it (as for example ecclesiology) as bear upon buildings, or decorative art. An excellent statement of the nature and claims of all these branches of knowledge will be found in the Architectural Institute, which he read before us two years ago, and in one which, a short time previous to that, he had read at the Architectural Museum.

In these studies, in fact in all the studies I have urged on your notice, great help is to be got from books. A few of the best books of reference ought to be part of your earliest acquisitions. The following list is in no way exhaustive, or in any degree of importance of one class of books above others, but it makes a much larger library than you will be able for many years to hope to acquire, or would indeed need to possess. Gwilt's Dictionary is one of the most universally useful books we have; Dobson's Art of Building, and a few others of Wiele's Handbooks enumerated in the Institute list, are desirable and not expensive. Next to these I should place (if you read French) Viollet-le-Duc's 'Dictionnaire,' or, if that be too costly, Da Caumont's 'Abécédaire.' Rickman, 'The Grammar,' Paley's 'Mouldings, and some of Pugin's books are among the best known handbooks for English Gothic; and the best guide that I know of for English Gothic is 'Parallels.' Nesfield's 'Book of Work,' and Shaw's, are good examples of draughtsmanship, but very far inferior to Sharpe in analysis and arrangement.

For Classical styles, Chambers, and a compact edition of Stawart and Revett's 'Athenes,' are good to start with, and to these you can add Sullivan's 'History of the Styles of Architecture,' which I have had ever since boyhood as my chief guide. If you go on of course many authorities and books of all sorts will have to be consulted. I have merely named the above, that you may have some idea of what to turn to first; but besides books of reference and books of engravings, you will find it interesting to peruse some of those works which treat of our art, or in portions of it, in itself a very large one, such as the histories, biographies and general works on art. As examples I will cite the historical articles in Viollet-le-Duc's Dictionary; Mr. Pettit's books; Mr. Ferguson's Handbook, and other works; Street's 'Brick and Marble Architecture,' Scott's 'Westminster Abbey, and his 'Domestic Architecture;' above all the early portions of Ruskin's 'V鼻子九·nine,' together with, for more miscellaneous reading, the best of Ruskin's other works, Sir Joshua Reynolds' 'Discourses,' Cellini's 'Autobiography,' Roscoe's 'Lorenzo di Medici.' All these, as soon as you have acquired some facts and want to know more, will be read with pleasure and profit. But mark me, till you find those you give you pleasure these books will be of use to you, but not as estimable a performance as I have just said. For purposes of study, I doubt if photographs are so useful as moderately good engravings. They are it is true wonderfully faithful, but their effects can only be approached by a draughtsmanship more finished than most students can boast; and I believe studies from prints and plates should be encouraged. Better than being less disheartening to make, and partly owing to their being selected subjects, which in the case of prints are given in the shape of studies, and in the case of casts are in the most advantageous state for being studied. But photographs will serve better than most things, the very important purpose of assisting the student to surround himself by specimens of architectural forms. I hold it of the greatest importance that there should be some beautiful objects about in your room, upon which your eye may daily fall and constantly rest, so as to correct some of the deadened perception of beauty and vivified taste which we cannot hope wholly to escape, living as we do in cities, and to which it is impossible to become insensible, for an age when almost every common article of furniture, of dress, and worst of all, of ornament, is either utterly worthless, or far worse than worthless. A few good photographs, two or three good casts, and some bits of good Japanese, Chinese, or Indian colouring, in papering or screens, or a bit of carpet, need not cost much, and they will save you time.

Let no scheme of study be so arranged and prosecuted as to become a weariness and to excite disgust. You can hardly become tired of drawing if you only select good subjects; nor can you well draw too much. But of most other sorts of work you can do too much; beware, therefore, of this, and be especially careful to incline in your reading those books which interest the reader, which enlarge and elevate his view, and which are written with enthusiasm.
If, however, all this be pursued with diligence and success in your own rooms, or in libraries, or by the help of lectures, there remains upon you yet a third and a more difficult, and from which your book-learning will lose half its effect. I mean the study of buildings themselves. You must draw from entire buildings, and you must draw from separate portions of buildings, if you are ever to make good buildings yourselves.

London presents few fine subjects for such study, but still enough to give you a very good idea of the various methods of treating of various parts of a building, and how to begin with, there are very few examples here, but in the chapel in the White Tower we have one of the purest and simplest specimens of Romanesque work that England contains. A few fragments may be found at Westminster, and a little good work by going as far as Rochester, but there are excellent casts at Somerset House and Sydenham in style; however, Westminster Abbey presents examples of the highest value; nor is St. Saviour’s, Southwark, to be overlooked. Leave to draw in the Abbey is easily got, and in the summer months leisure to go there will usually be readily granted by any master to any pupil found making good use of it. Avail yourselves of this privilege to the utmost, for what you cannot learn there, especially of its interior, to your sketch-books. Of Italian work we have some excellent modern examples in the Pall-mall club-houses, and earlier ones, but with less accurate detail, in St. Paul’s, and Wren’s churches.

The Roman and Oriental architecture we have no specimens visible, except some fragments of architecture, and many noble works of sculpture, in the British Museum; but both of these and of other styles we have the most extensive, complete, and classified series of casts which the world ever saw, in the Crystal Palace. It is an excellent place to see and to sketch in. Leave to do so is readily obtained, and it appears to me extraordinary that so few pupils avail themselves of it. I hope you will find castes are a very excellent means of accomplishment for some series of architectural examples. The Architectural Museum casts are readily accessible, and among them you will find much to work from. But at once the pleasantest and the most useful mode of studying buildings, is to join some friend, if a little more experienced, as a partner than yourself so much the better, in an architectural walking tour, and to spend your summer holiday in that manner, or, if it suits you better, to go alone. No more pleasant way exists of blending recreation and improvement, and nothing can do so much to keep alive and increase your own interests in your profession, and to awaken in you that enthusiasm for it which will enable you to hope to reach the highest eminence in it, as this mode of study.

At some period, probably after not less than four years—and it may be after a great many more—the student should make a long journey, principally on the Continent. This is happily a tolerably well-recognised custom. It is one which cannot be safely omitted, as it will give the first great experience of every sort of objects, and this if it is not practicable, the assistance of a skilled observer, familiar with the building, and who will draw your attention to its remarkable parts, will help you very much in your observation of it. The sort of sketches you should take will be determined by the nature of the object you are appropriately used as studies of detail or ornament; others, and these the best, are also as useful, as teaching general design. These last you can often best study by first making a rough plan, if there be any peculiarities of plan, and then one or more sketches in perspective of interior or exterior, or both. But I am disposed to recommend beginners to make the principal part of their sketches, for some time to come, geometrical, and not in perspective. This mode has the following recommendations—it is the mode of working to which they are most accustomed, it produces very practically useful drawings, and most important of all, it cannot be done without the student’s devoting some amount of thought to the work. I should therefore recommend the attempt, especially with moderate sized portions of buildings, to reduce them back—in studying them—to the same drawings which you may have made for the rough plans, for the original construction of them. Take for example an entrance to a church, studied from outside, the sketcher having a block, a two-foot rule, a small T square, and a bow pencil. I should first roughly measure or pace out the width, and then, retiring a little away, carefully compare the width and height, aiding myself to this by a two-foot rule, marked on the side, parallel, as parallel to the building as I could get it, and vertical, hanging perpendicularly. This tells approximately what height and width I have to provide for, and consequently, to what scale I must work in order to get it all in on my sheet of paper. I should then measure and draw to scale with as much care as was requisite the distance of the door from the lowest step, and altering, as the height to which the door extends, putting it at the bottom of the paper. Then I should rule up the vertical lines, and, as far as I could reach them, measure the heights. Whenever I could, above the points to which I could reach, I should ascertain additional heights by any such means as counting courses of bricks, or if there be such counting uniform courses of stone, or by measuring the height of the courses, and taking the number of repeats, and calculating the dimensions by the number of repeats. In this manner you will get up some way; for the remainder a trained eye, and the careful use of your two-foot rule hung up at arm’s length, as a scale by which to compare ascertained dimensions with those not so exactly ascertained, will give you your heights to within a very few inches. I should turn in the curves, sketched to a section by the side of the elevation, and should afterwards proceed to draw very carefully, as separate studies, the profiles of the mouldings, sections of mullions and tracery-bars, and caps and bases; and in fact, as many details as time allowed, or as there were to be got into, whenever possible getting up to the mouldings with ladders, &c. I am persuaded that this plan pursued for some time will help the student thoroughly to understand the buildings he has to draw in the early stages of his out-door studies, and also thoroughly to understand the nature of geometrical drawing.

As proficiency advances, you will feel more and more able, and more and more inclined, to draw in perspective, and this is the mode of study most natural and most pleasant to the advanced student; but you should always bear in mind that it is more possible to miss the peculiarities which give rise to an architectural effect, when you are working in perspective, and drawing giving itself, without being obliged to satisfy yourself as to how it was produced, than when you are studying in the analytical method I have just described. In perspective work you will find a camera lucida very useful. Occasionally a finished outline of a very difficult subject may be completed under it, often, perhaps usually, its use will best be found whenever possible making up to the mouldings and figures them, and make a memorandum on the sketch of how many feet the curve is, and when possible the angles placed. He should also observe the effect, the light and shadow, the air of breadth or of intricacy, of richness or of simplicity, of strength or of weakness, which each group of mouldings possesses, and should note, as far as he can find it out, what causes produce the effects of which he observes.

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

These studies will mostly be made in pencil, but, if the student can color, he should make colored sketches from nature along with his other work. If you have not made the habit of sketching standing, which is easily learned, it will save you, when working in a town, from much annoyance, for you are much less readily seen, and it being much more difficult to look over your shoulder, you are much less liable to be molested by the curious than when you sit down.

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

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

I have now gone through the leading outlines of what can be learned in the office, what on the scaffold, what in the lecture room and your own study, and what in your sketching rambles. It only remains to add a few concluding remarks. The first is, that when you have completed any part of it the first to be always looking at what you are doing is to be done, or what seems beyond your reach, but concentrate your attention on what you are learning now, and what is within your reach. None ought better than an architect to understand the proverb, "Rome was not built in a day." Rome was built, and so will your education be accomplished if some part of it is done daily.

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

I feel that I must pause for a moment to inquire, Have I drawn too favourable a picture of the acquirements attainable under your present much-decried system? I think not, and the best answer I can give is that very many skilful, educated, accomplished architects exist at the present time in England, who have learned all they know in the manner I have described to you, except only that few of them had the advantage of attending the lectures, the classes, the public libraries, and the Institute examinations. Yet of course a large number fail to profit—some of them, if there were a schoolmaster over them to hold their noses to the grindstone, would learn more and perhaps do better, but these are not the best class of men. The peculiar advantage of the English system is, that it brings to the student very early into contact with actual work, and throws him to a great extent on his own resources. These are just the circumstances under which a genuine English nature thrives best. At the time when one of you is preparing actual working drawings, and visiting actual buildings, and improving his leisure as seems best in his own eyes, a well-instructed working exterior, he will try to restate its value by reminding you of a well-known speech of Demosthenes, the great Athenian orator. Of him it is told, that one asked him what was the first essential of an orator, and he said Action; and what the second, Action; and what the third, still Action, was his reply. Just so, and in the same sense, I would say that the first essential of an architect is Drawing, and the second Drawing, and the third Drawing.

Achievements.


The above production of Messrs. Westlake and Purdell will be hailed with much interest and gratification by all concerned in the study of Medieval art, or associated with re-introductions drawn therefrom, as placing within easy reach a very valuable task. It is suggestive of original composition, and has a proper spirit and to secure its characteristic sentiment and expression.

It is an especial desire, indeed, necessity, of the present day, that reference should be had to such authorities as are here exhibited, and it is therefore unnecessary to enlarge upon the fact of how much good services it performs in the field of art who, in however small a degree, disseminates, or to use an ordi-
nary phrase "popularizes," the knowledge of the treasures we possess of this kind. Messrs. Westlake and Purdies are eminently entitled to thank the author for this score, although the arrangement is by no means a limited one—on the contrary, must have entailed an amount of labour and untiring perseverance which those only who have tilled on similar ground in like manner can form any just conception of—but that it is one also which especially heralds the proper direction for our thought and study. The whole is of the highest and legitimate standards by which to hold and regulate our course.

Having premised so far, it may be necessary that we now take a more particular view of Messrs. W. and P.'s publication. It is, in fact, a copy, so far as outline and chief character and expression is concerned, of the principal contents of the well-known M.S. Reg. 2 B. 11 Missel Brittanici, commonly called Queen Mary's Psalter, a work attributed by competent authority to a date corresponding with the best periods of Mediaeval art. The contents of this celebrated M.S. comprise a series of illustrations of Scripture history, each with its appropriate close, commencing with the fall of Lucifer, and ending with the death of Solomon—a beautifully illuminated object, such as are represented in the Psalter and Hymnal—and several very interesting and highly coloured delineations of the prophets and saints. The first mentioned, were, with the Litany, in part brought before the public by Mr. Westlake in 1858, and have since been completed by Mr. Purdies.

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

It is, perhaps, to be regretted that the colouring here mentioned does not appear in Messrs. Westlake and Purdies's work. It would have been very useful, as showing how far considerable additional labour and charge would have been required to make the illuminations, but there is as yet a very considerable demand for work of comparatively little labour. On the other hand, we perhaps see the drafting capability of the mediaeval illuminator more clearly, thus divested of the aid derived from the coloured finish. Another omission is also to be regretted. In addition to the Bible Histories, at the bottom of each page of the original are a number of very curiously illuminated objects, such as are represented in the Bestiaries, and the M.S. illustrations of the Sports and Pastimes of the period. Some of these are highly interesting in treatment, and the variety and originality of design is very extensive and instructive. As in the case of the Calendar also of the original M.S., where the head-piece of each page contains a representative period of the months; and, further, the Zodiac, &c., they are particularly worthy of attention and study, and would have added considerably to the general value of the book, viewed as an authoritative example for like introductions.

As regards these subjects, however, which we have represented to us, with so many calling for notice on account of their general treatment, or other more specific merits, it is not easy to make choice. We may refer, nevertheless, to Plate XIV. of the series, for the grouping of the five figures on the right of the centre tree, "The men of the law" wondering at the act of Abraham breaking the false gods "on despyt;"—the similar grouping in Plate XXVIII., where Joseph's brethren exhibit his elocution stained with blood to their father;—the four figures in plate LXXXII., where Sampson shows Delilah to his father;—the Plate CXIII., where, in the upper picture, Solomon is directing the building of the Temple, and, in the lower, receiving the visit of the Queen of Sheba,—in both of which the arrangement of the dresses is treated with great finish and traditional correctness. The original, which is not shown in the copies, is clearly the case of the reclining Jesse, his head resting on an embroidered cushion, a rising tressliss issuing from behind, enclosing in its convolutions nine figures. There are no names attached to these latter. David is, however, identified by his harp as occupying the centre compartment of the first range. Our readers will be able to judge for themselves of the suggestiveness and value of this example from the illustration (Plate V.) which accompanies this notice.

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

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


The work before us is a valuable addition to our knowledge of art-decoration, and likely to be of great use to stone and wood carvers as well as to all other workers in ornamentation. Mr. Colling has gone deeply into the subject, and has very clearly elucidated the principles which should guide the art-workman in the treatment of natural foliage for artistic purposes, as which he explains must, more or less, always be made geometrical, and arranged with symmetry in accordance with the laws of perspective. Studied in this manner, the foliage is the arrangement of the branches which constitute the leading lines. These constitute the skeleton upon which the whole is formed, and they should be made such as will best harmonize or contrast with the architectural or other lines which surround the composition. In the second place, the forms of the leaves and flowers have to be considered, and to be altered at the pleasure of the artist, as circumstances may require.

Then there is the position it is intended to occupy, whether internally or externally; whether it has to be placed close to the eye, or at a distance; and, lastly, the material in which the ornament has to be executed.

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

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

In illustration of his subject, Mr. Colling has not limited
himself to style, but has sought for examples among the Egyptian, Assyrian, Indian, Chinese, and Japanese—as well as the Greek, Roman, Italian, Byzantine, Romanesque, and Medieval. Besides this there are constant references throughout the work to leaves, flowers, and other objects in nature which are adapted to the use of the ornamentalist, and the book concludes with a series of plates, consisting of some valuable examples of natural buds, ferns, leaves, flowers and fruit, which appear to be selected with great care, and to contain excellent suggestions, if worked out and studied in the same spirit as Mr. Colling's own designs from nature. Nothing, however, can be more clearly conveyed, if merely copied from nature, without being translated by the mind of the artist, than the greater care than the art of adapting forms from nature; for, as the author truly says, "Natural foliage, however well rendered or cunningly carved, if merely copied from nature, without being translated by the mind of the artist, will fail entirely in its purpose, and be less effective than the literal copying of the foliage from any of our architectural precedents."

Pork cannot be too strongly insisted upon, because, if we tell our artists that they should not copy from old examples, but simply say, as it has often been said, that they should 'go to nature,' we should soon be so deluged by literal representations of natural foliage, that this system of copying would become worse than the first. In the rendering, then, of natural into decorative foliage, there must be a profound and original thought with more beauty. It must be the creation of the artist's mind, and not a copy of this plant or that flower.

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


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

CUT-OFFS.*

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

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

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

It will be understood that I speak here of natural steam, not of that Doctor Bredt and more or less decomposed after actually or virtually leaving the boiler,—steam, of which every cubic foot contains, in round numbers, a cubic inch of water, and in the using of which nothing is left in doubt,—steam; identifying, steam, whatever is increased by increasing its quantity, just as much heat is obtained by consuming more fuel, more light by burning more gas, more wind power by enlarging sails to catch more of it, as the force of a gun is increased by adding powder to the charge, and that of men and animals by increasing their numbers. To double the power of steam, the fluid must be doubled. Such we take to be the only reliable theory of forces, whether the motive agent be an elastic fluid, a liquid, a solid, or a living body.

Yet vast amounts of time, talent, and money, have been and are still being spent to prove steam an exception. Superheating it may, in certain cases, be done to prevent demagnetising, but its value as a prime mover is thereby increased has yet to be established. It adds nothing to the substance of the fluid. Another query is, whether any alleged gain does not cost, all things considered, as much or more than it is worth.

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

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

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

The next dictum is specific, and not to be misunderstood. Could it be proved, a chief niche in the world's Walhalla would be due to its author. That by the same quantity of steam more than the twice the work can be performed with a cut-off than without one is incredible, and if true a miracle almost as great as making three gallons of water out of one. If the resistance were greatest at the beginning of the stroke, and fell down to zero at the end of it, there might be cause for some gain, but so far from that, it may be considered uniform in bodies moved by steam, whether ploughs, ships, or manufactures.

Whatever may be said to the contrary, we must continue to believe, till controverted by facts, that there can be no saving of steam power by substituting a succession of impulses for continuous pressure, except in cases where the resistance rises and falls with the piston's movements. Whether there are such cases we know not, but it is certain that sudden changes of force and velocity are not the things for steam machinery, no more than are springs and leaps (sensible or insensible) for bodies moved by it.

The popular idea is illusive. It is the impression of many that when cut-offs are at half-stroke, half is saved at one-fifth, two-thirds at one-fourth, three-fourths at one-half. They forget that pressure indicates quantity. Engines with cut-offs of necessity use steam of greater tension than others, and the less the charge the greater the tension. The only difference is that one class uses small volumes of high pressure, and the other large volumes of low pressure. The requisite quantity being the same in both.

An engine is worked with steam of 100 lb. on the inch for cut-offs off at half-stroke. The mean pressure of the latter half is, therefore, 75 lb., and that of the whole stroke 87 lb. on the inch. Observe that twice the force is expended on the first half than suffices for the latter half, and (the resistance being the same) twice the amount required. Where then is the difference in the amount consumed between charging the cylinder with 87 lb. steam, and with it varying from 100 to 50 lb. In every case as much of the fluid must be admitted as will push the piston to the end of the stroke, whether soon or later cut off. Another engine has a cylinder of the capacity of 12 cubic feet; and requires steam of not less than 12 lb. per inch pressure. This does work without a cut-off. Suppose it be determined to apply and cut off at half-stroke, would not the tension have to be to 24 lb. on the inch; if cut off at one-third, to 36 lb.; and if one-half, to 48 lb.? It does not follow that therefore there is no more to be gained by cutting off at a quarter than half-stroke, and no more by that (unless in special cases alluded to) than with no cut-off at all. To determine how far practice conforms to theory there is a conclusive experiment—apply the same quantity of steam used with a cut-off to the same cylinder without one.

THE ARCHITECTURAL ASSOCIATION.

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

The report of the sub-committee, appointed on the 24th November to make inquiries as to the publication of the transactions of Architectural Association, was read. The Secretary stated that arrangements had been entered into with the Editor of the Civil Engineer and Architect's Journal, whereby the Journal would contain authentic reports of the papers and discussions thereon. Lemon proposed, and Mr. Faver seconded, the adoption of the Report, which was unanimously agreed to.

Mr. Riddell announced donations to the library. The Chairman then called on Mr. J. Douglas Mathews, hon. sec., to read a paper for which the prize of the Architectural Association had been awarded to him. Mr. Mathews' paper will be found reported in another part of the present number of this Journal.

Manchester Architectural Association.—The annual meeting and conversations of this society was held on the 20th ult. gathering was very successful. The contributions of drawings and models were very numerous, and generally exhibited with great neatness. A series of three pictures, by Mr. J. Redford, from sketches taken upon the spot, illustrative of the rise, culmination, and decline, or, as it was termed, "the morn, noon, night" of architecture were displayed, and indicated careful study on the part of the artist. Singularly, for the period "night" was employed a scene taken from the river Ir, which will be familiar to anyone acquainted with the neighborhood of Blackfriars Bridge, Manchester; the "Palace Gold," in Venice, which is a masterpiece of constructive inutility and colouring, being selected as the epoch when science was at its "noon;" and a Canadian log shanty, with solitary settler, represented "morning." A collection of splendid photographs were shown, representing various scenes in California. Amongst the other contributors were Messrs. Dar-shire, Gregory, Clay, Newton & Co., &c., &c.—Mr. W. Booth, the president, delivered his inaugural address, in which he deprecated the system of cheap architecture adopted by some of the members of the profession. The system, he said, was a cheap after all; but if there was any sacrifice to be made, it should be at the expense of ornamentation. He congratulated the Association on its prosperous condition.—Mr. J. Boul, president of the Liverpool Architectural Society, thought that Alliance meetings should be peripatetic, and not confined to a particular place (as London), that there were more than three intercourses between them—Mr. Bowman, Dr. Clay, and other gentlemen also spoke; and votes of thanks were accorded to the contributors and the president.

Exhibition of French Art in New York.—An arrangement has been made for an exhibition of the works of French artists in New York, and the Moniteur des Arts de Paris says that M. Curtin, one of the editors of the Société des Artistes, will lend in a few days for America, to organise the exhibition, which is to open in March. He takes with him about two hundred pictures, by the best living artists of France, and represents the school in all its phases. The idea is certainly a good one, and if well carried out is likely to furnish French artists with new and important market for their works.
ON IRON: ITS LEGITIMATE USES AND PROPER TREATMENT.

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

Having now vindicated the cause of iron, as well in its legitimate use as from its growing abuse, I must endeavour to sum up the chief of the evidence of the value of the material, and the several processes which can or cannot be justified by a strict observance of the distinctive qualities of the material. It is difficult to lay down dogmatic and unerring rules as to what is right or wrong in principle; or always to say whether such rules are infringed or not in a given instance. It may, however, be stated that the use of iron, in its state of cold or finished file, is consecrated with the highest degree of perfection by the best established laws in that branch of mechanics which has been called metal, or smith, or forge. To the workman's hand in the forging of it; and it is in design and fashion such as to preclude the probability, if not the possibility, of its having been cast or impressed,—whether by its delicacy of form, or its vigour of finish. Even in works of massive work or strength some even of the most expert of the overlapped forms which have shed the strength to its will, whether it be by hand-drawing or taping, or by some little playful conceit which the workman indulges in, thus stamping it as his own.

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

Having briefly outlined the several kinds of iron, and their respective treatment, the all-important question presents itself of the bearing of all this on the subject of the inquiry and of the position and province of the workmen employed upon it. In considering this branch of the subject we must bear in mind the truth that in forged work there is genuine art to be displayed. There is room for delicacy of expression, and for the exhibition of the forger's power, which is not possible in a massed process, and which, indeed, is all the more distinguishing art from mere mechanism. It is equally true, however, that great skill, together with great knowledge and experience, is required in the fitting of castings, or of machine-cut details; and, when well done, skill is evidenced in the absence of imperfection and irregularity, rather than in the presence of either. But there is one important particular to be observed, viz., in forging the iron is made itself upon the otherwise inanimate metal, bending it to its will, and by the presence of a living power which has made itself felt upon the iron, a certain degree of fitness and suitability is imparted to the work, which, however, in the case of cast work, are made to supersede the hammer and the tongs. The indiscriminate use of the file, indeed, has given rise to a false taste in metal work very much akin to that of scraping of the stonework of the noble minster fonts of Lincoln and Winchester. Let me, however, be not misunderstood. I am not object to any one using the file; but its aim should be to produce a smooth surface, and not to roughen a smooth one. So I would now again take the opportunity of repeating,—the file must be used only as an means to an end, instead of being, as it too commonly the case, the end to which all metal surfaces must be brought before they will pass muster with a misguided public. The file may be, and must be used for fitting and jointing, and the perforation of plates, and other fine work such as the hammer could not touch; but the use of the file for finished surfaces is one of the first things that has to be abandoned before the forger can assert his rightful claim to our regard. Such treatment of surface is of the highest consideration in all art works, such as the work on stone, and, stone, or metal. In any other case, the file is only used to impede the work by its being imparted by texture. In hard wares it is to a great extent given by implement and manipulation. A high polish presents one kind of beauty, and a rippled or broken surface another. A merely crude and neglected surface does not satisfy the eye. Labour of some sort must be bestowed; but only in a proportion to the pretensions of the work. Whether in stone or wood ought commonly to show the marks of the chisel or tool, and if these are scraped or filed or sand-papered away, the play of light upon the surface is dissipated, its character is impaired, and its surface measure, so to speak, over which the eye has a pleasure in travelling, is actually diminished in effect. So, too, forged work ought to show the hammer marks, and wherefore should the roughness of the fire marks be filed down, when, by cold hammering, its surface can be greatly hardened and its tone deepened, its play of light increased, and a polish of a totally different kind far superior sort imparted,—a polish not of mechanical labour, but of handiwork! And wherefore destroy the characteristics of the work, instead of allowing and strengthening them? But this might be effected by the merest apprentice or a human machine!
tion of his work being needful, as the hand of the sculptor is in his case much larger and more powerful, as well as far more limited in his present moment, scarcely concerned, further than to call attention once more to the importance, which our present President has so often and so ably urged in other places, of promoting, by all the means which we can command, the education and the recognition of a class which has till within these few years almost entirely disappeared from society—the class of artist-workmen. 

The mechanic, as commonly he is in nature, no less than in name, has, in taking the place, altogether usurped the province, of the artist-workman. There is room for both; there is need of both: but at present we are reduced almost to the one. The question to be considered is the relative position and the distinction between hand-work and machinery as regards effect when finished. It is a mere mercantile calculation as to whether machinery or hand labour shall be employed in the execution of a given work, and has no regard to the best suited form for the purpose, or to the art of making it, to the cost, to the labor involved, to the best suited form is good and suited to its purpose. The cast column, even, might be used, and then covered with plates of finer material, so that these be not made as independent cases or cloaks to give an air of decoration to that which is only decorative, and yet withal very legitimately is decorative. Nothing, however, can approach to the deliberate art, that is the art which gives the real suitable, that is the art which gives the real, and that is the art which gives the real such an illustration. In this we have not only pretentious cupolas and columns of a wrought construction, but even the apparent rivets with which it is pretended they are fastened together. I would not add a word on the unpardonable parodies uttered in the shape of would-be hinge bands; but that every testa is a testa and its place, and that each piece of such and such a construction is not yet reached and which may yet profit by it. And unhappily, this is a delusion still practised upon those who know no better, through the catalogues of manufacturers of such wares,—the delusion that a cast-iron hinge band adds one whit to the architect's effect of a door, and does not rather destroy all that might be otherwise good about it. The "small cost" is used to justify an expenditure which would be much better saved altogether. The small cost would be much better expended on sending them again to the furnace; for such work becomes a species of trickery, which is quite alien to the true spirit of art.

The grand aim of art is not directly to instill, but to image. Not to deceive the eye of an intelligent being, but to present or re-present to his imagination an idea which is worth reproducing or perpetuating. If the means used are opposed to or inadequate to the end, the imagination takes offence at the desired failure. And if such poor artifices are used, the taste becomes depraved; and I believe it would quite possible for the artist to get into a way of living upon fallacies, as the opium-eater upon his drug, till his art-life becomes a morbid state of existence, rather than an existence of energetic enjoyment of its realities. These amongst many prevailing instances of a state of sham pervade our modern iron work, and hinder its rising so rapidly as it might to the position in art which it ought to occupy. And although, as I said, I do not find fault with the state of things as regards machinery and its necessary application to all useful purposes of daily life, yet I do object most sincerely, most strongly, to the system so largely adopted of imitating forged work on a large scale by the bending, gauging, cutting, screwing, and bending, and moving machinery. All that machinery does, work, which is disappointing and insulting, from its tame and leafless character, while it promises and professes at first sight to lay claim to our respect as a genuine work of art. And such, alas, is the practice of all or nearly all of the monopo-
lists of so-called Medieval metal-work. The intelligent working artist takes in hand a corona or a grille, which shall impress people with the idea that it is forged by the hand of the expert smith. The work is completed. The popular voice, expressed with all sincerity, "how pretty, how neat, how exquisitely finished," prepares us for the evidence of its having been机制机械地, but a single idea, from one to another. In this case, may be inserted into form, by layer or die, folded, bent, crumpled, filed up and fitted, and finally put together with nuts and screws, by a process of mental machine work, such as might do credit to the most skillful manufacturer of cast and machine-made wares. But the living working artist, where is he? He is degraded from his past of honour. He is become again a mere mechanist, just when he began to flatter himself that he was rising to the
rank of artist in his profession. Let us leave him there,—for he can scarcely come forth again to higher aspirations. Let us draw the curtain over this sad, this humiliating picture.

The materials used in the buildings from about the year 1800 till the early part of the present century, was very different. Look at the wrought iron gates of our country mansions, or even at the ironwork which still graces many a house, not yet a century old, in London. Look again at the fine medieval hinge bands as an illustration of proper treatment adapted to the several parts. The ornamental part was usually cast, and fixed in place or fastened on, and the joint was covered up with a cosmetic, but the terminations sometimes were stamped and cut with tool and die made for the purpose. Both of these processes required equally the hand of the skilled workman to use them. The terminals sometimes were apparently first cast in a mould, and then worked up and fastened on in their respective position; and then the jointing of such surface treatment as could be stamped. In none of their stamped work did they ever aim at tortuous bends, or other forms, such as properly could be cut out by forging alone. But there are some who, at the present day, would not scruple to reverse the process, to forge the terminations and to cast the scrolls, if we may judge of them by what they do and say in other ways.

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

One of the most common forms in which cast-iron comes before the eye of the beholder is that of 250 feet high, four-sided, and surmounted by four turret-like spires, that stand on the area of every ordinary dwelling-house in this Metropolis and other large towns; and the question naturally arises, how far that form is justifiable. In answering this we must bear in mind that expense cannot be entirely set aside, however much we may desire it; and that the difference between wrought and cast for the purpose referred to would be, perhaps, some three hundred per cent. in favour of cast. Are we then reduced to the dire alternative either of doing a great wrong to art, by abandoning our principles, or of incurring an unjustifiable expense. I think not. Only, if this cast-iron pretends to be wrought, it is an egregious sham; for instance, if it presents the spicuous point or the clustered flower, it stands to be seen as the same, and not to be turned out, from the forge, and the forge alone. What would be said by a brave warrior of old, could he now see, bristling on all sides of him, the common but contemptible device of a cast-iron spear, with a cast-iron tassel dropping from its head, set side by side by the neck to line the footway; with mimic ure, it may be, for the standard ends? We may well hope, however, that the day for this is past. One mode of obviating this objection to the upright bar is to have, instead of the bar at all, some impressed pattern of genuine cast-iron design, which itself will be artistic and more ornamental. We must, however, remember that the main, I may almost say the sole reason for a low and ornamental pattern to a London area is, in many cases, indispensable, is as a mere matter of security. Anything which would afford easy foothold, as all or nearly all cast perforated patterns must, would afford facilities for the ingress and egress of those who are disposed to those of the nature to a large extent. It is to keep such out. But this seems a reason why the upright bar should be of the common round or square section of wrought form, rather than of a flattened, patterned, design; nor why the top of the bar should not be cast in some such form as to show evidence of its impressing, instead of imitating that of a kindred metal. We must, however, for such cases, meet the case fairly and upon its merits, and we shall find that so far from our art suffering degradation by making use of available means, it will be in reality exalted and ennobled; for then we shall have to contend with those only who are afraid, or ashamed of the tenth.

ON TIMBER AND DEALS. *

By T. A. BRITTON, M.R.I.B.A.

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

The soil in which timber trees grow, has much to do with their quality, different soils producing different effects upon the timber; the climate likewise in some degree determines their strength and fitness, inasmuch as the moisture or sappiness will be retained in the tree, according as you choose; the tree, therefore, would not suffer in the climate. The position of a tree with regard to the compass will slightly alter the character of the wood; for instance, that part of a tree fronting the north is always found to be red, and to produce the hardest and most durable timbers, as all the moisture is pressed out, and the wood made more compact, the concentric rings are driven together; but that part of the wood which is warmed to be white, soft, and sappy, and the concentric rings further

* Paper read at the Architectural Association.
apart. It will thus be seen that the heart of a tree is rarely in the centre. Where trees grow in forests, and are closely studded, and where they grow alone, and are exposed to the weather, the wood is more Uniform in the different positions. It is very probable that the trees stand so closely together, that the rays of the sun cannot penetrate, and are situated in a good soil; the wood obtained from thence is always of a very tender nature, by reason of the continual shade, which makes it so, and is only proper for jointry. But where the trees grow alone, and are farther apart, the wood will be hard, and fit for carpentry. The tree that grows in low situations, and grows rapidly, is never found to be so strong or so durable, as those growing in exposed situations and drier soils. All the oak in the north is much stronger than that of the middle counties, and is closer grained than the oak in the south. The tree is strongest and most durable when the growth is gradual, and it is taken from the oldest places. The wood is generally bad when taken from a clay soil, as it has too much moisture; it is also bad when taken from the rich black loamy soil, for although the tree grows fast, straight, and large, the wood is too sappy, the soil being too rich for it. Generally speaking, the wood which is the longest growing is the hardest, strongest, and most durable. The driest woods do not last long, they easily rot. Those woods which are moderately dry are the best, there is more strength. Moderately dried wood is better than green for carpentry. It is a curious fact, that there is not much wood which grows best in the middle, amongst trees which differ not much from each other, difficult to discover whether a piece of timber is sound or not, unless it be sawn into scantlings; you cannot perceive from the exterior, its interior faults; you may, perhaps, see certain splits or shakes, which might be thought to indicate unsoundness; but if the timber is used as a beam, and the splits are of slight extent, they are not of great importance, owing to the large scantling of the timber. Where these fissures exist, the timber is used for beams, rafters, or quartering, but not for thin boards.

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

All those who convert timber into deals, &c., will know that a great quantity of the converted article is useless, or greatly faulty, on account of the inward decay of the wood from rotten knots, or the cross running of the shake. The more free timber is from knots, the more liable it is to be shaken at the core. Knotty timber is less liable to these defects at the heart, because it is said, that the knots serve for bolts throughout the timber, to keep all the parts together. The wood which is just under the heart, where free from knots, is the most. It is impossible to find out the quantity of knots in the heart of the wood till it is opened, but we know very well that on the surface there is the freedom from knot, in consequence of the tree not having shot out the knot or branch to the surface. The knot is the remnant of a branch. When the dead branches of the tree are cut off, the growth is cut off at the extremity of the broken branch, and remains clear of knot. When you recede to a certain distance from the centre of the tree, you find the wood most clear from knot, and might, in size, or altogether. American fir is of a soft nature, and very free from knots. That which is free from large, loose, or dead knots, is the best. The timber is here not to the other as not to the contrary, and is stained by the name of fir or deal; the American fir is known by the name of pine timber, and, as deals are the form in which it is most conveniently imported (both from America and the Baltic), the word fir or deal has become the common name for all sorts of pine timber. The conversion
of timber into deals takes place abroad, it would not come in a fit state for sawing. It is there cut into the proper thicknesses by machinery, and is afterwards cut down in this country into boards of various thicknesses, to suit the purposes required. If the logs are long enough and thick enough to be sawn, they are cut into rough or round deal lengths, and these sawn into more manageable lengths, and manufactured into deals here, it would deteriorate the quality of the deals. A deal sawn on the spot is certainly better than one sawn here, because there is a considerable outside shake, which takes place from the log being exposed to the air. They are in the habit of picking out the best timber, to be converted into deals, and sometimes it is to be seen in the wood, and it is for the round state; if square timber is used for that purpose, it will be split and injured when it is floated down the rivers, and consequently unfit for cutting into deals. If the deal is not cut from the round log, and also as quickly as it can be from the time of falling, the grain will open, and the wood will be shabby, and when cut into thinner boards it will be fit for pouottage. The round logs were brought soon after felling, and sawn quickly after arrival, this evil might not occur; but the freight would be nearly doubled, if not quite, and we should be paying this large freight upon sap, wastage, and defective parts; that is, upon the parts which prove to be defective after the log is divided, and which, even if the wood is converted abroad, are not shipped, but kept back.

As the lengths of apartments are different, so great variety of lengths are required to work in advantageously, European deals, which are imported from ten to twenty-two feet in length, and from three to fifteen inches in breadth, and American deals from ten to thirteen feet in length, and from six to ten inches in breadth. Deals coming from St. John's, New Brunswick, are from twenty-two to twenty-four feet in length. Besides the deals exported to England and France, there is a third kind, too bad to be used for building purposes; these deals are cut up into firewood, which is exported in considerable quantities to the London market; the firewood is cut from the bad deals, which arise from the timber being rendered useless from rotten knots, or splitting at the heart. These deals are likewise exported in another form, viz., deal ends, which average six feet in length, though sometimes much shorter, and are about five-and-a-half inches wide, if inch boards, when they arrive they are sawn into two 1/2 inch deals, which is the thickness generally required for floor boards, and as an enormous number of 1 1/2 inch boards are thus used in buildings, it is probable that by lapse of time 1 1/2 inch deals have been by workmen taken to mean whole deals. "Slit" deals are generally 3 inch thick, being obtained by sawing down a 1 1/2 inch deal. All thinner boards are termed "veneers." "Tongue" stuff is thin stuff used by joiners for tonguing. What is termed by carpenters, an "offcut," is obtained by converting a 3-inch deal into 1 1/2 inch flooring boards; by means you obtain a board 1 inch thick, the surface of which is rather difficult to make use of. Having, I believe, named all the varieties of deals, I shall now briefly consider their defects.

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

Such being the defects of deals, it behoves us to consider what are their merits, or what they ought to be. The first thing to be considered is the quality of the wood. Many deals are of good quality for building, but they fit for nothing else. For instance, a coarse floor or carpentry, but are wholly unsuited for joiner's work, for when the saw has passed through them they warp, and will twist like a piece of whalebone. Such deals are termed "strong" deals, and possess the bad property of rending themselves to pieces as they dry, and become shaky. Deals that when sawn do not form, or produce but a small quantity of splinters, and such as do not split easily, are called "stringy" deals, and are in general of this strong nature. Such deals are less uniform in their texture, and vary more in the hardness of their fibres than those deals which are fit for the joiner. The deal, to be good, should be mellow, that is, soft and light, should yield easily to the knife or chisel, should be straight in the grain, and without coarse knots (which weaken the deal), and the more nearly it is perfectly clean the better. Such deals are characterised by their light weight, in comparison with the strong fibrous deals; and when planed they exhibit a silky texture. If the deal is cross-grained, it generally becomes shaken diagonally under drying, and fails to pieces under the pressure of even a small weight in a less degree than the parallel fibres, and together while the very water is running from it, and very soon after it is so converted it shrinks to such a degree, that every tenon becomes loose, every joint straights falsely from the skinkrage, and every ceiling and quartered partition cracks by the opening, diminishing, and distortion of the wood. The effect of this is very evident in the buildings soon after it is dried, and is observable in the Metropolis, showing itself in rents, which are caused to the timbers by the irregular strain in shrinking. Some persons state that the immersion of timber in water is the best method of seasoning it, and I was a few days since in conversation with a London timber merchant, who told me, that the way he seasoned his timber was to immerse it in water for a couple of months, and then stand it end-ways, out of the rays of the sun, but open to the wind and rain. He considered that a windy, showery day, such as we have had lately, was the best possible weather for seasoning timber. Timber for ordinary purposes, should be shrunk to its smallest limits before it is worked up: the least possible change should occur in the timber after the work is framed and adapted: for all the oblique joints, by shrinking, become imperfect, each bearing timber then having straining upon it at every point of fastening; and hence many of the struts and other bearing timbers rend, by the weight hanging merely upon their angles. Our specifications are very strict in the requirement of the perfection and proper seasoning of timber; but these precautions are almost useless, as the builder can hardly procure at any price timber which is not in a considerable state of moisture before it is sawed and worked. The rooms began to have an effect upon the beams, and this one in particular, and large shakes and splits opened, and the timber had to be restored, or rather replaced with new. This was, no doubt, owing to the unseasoned wood, which had probably been, within a week or two of being used, lying in a wet dock at some distance for instance. To prevent some such oak framing to a large public room, erected within the last five years in London. The architect was very particular in having, what he considered to be, a good piece of workmanship, and good materials, forming the front of two galleries; the work was squared framed, and when finished, appeared certainly a creditable production; but soon after it became subject to the latent heat of a meeting room, the joints opened, and the work has since been patched up with slips of oak inserted in the openings, some of which had opened nearly 3/ inch; all this undoubtedly arose from the unseasoned state of the wood.

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

For the purposes of joinery, seasoning and boiling are very good methods of seasoning, as the loss of elasticity and strength which they produce, and which are so essential in carpentry, is compensated by the tendency to shrinkage being reduced; the durability also is rather improved than otherwise, at least from steaming. It has been ascertained that, of woods seasoned by these means, none has been found to answer so well, and the drying in either case should be somewhat gradual, and four hours are sufficient for the boiling or steaming process. Stove drying, for joiner’s work, is also practised by many builders.

The mere seasoning of wood, though it will not altogether prevent its decaying; nevertheless, considerably diminishes its tendency to decay. When timber is put to any use, the longer it is exposed, the greater is the necessity of its seasoning.

The value of any process for seasoning wood depends, of course, on the extent to which the wood has been dried, and on the method of seasoning, and on the time required for its completion. Davison and Symington’s method for speedily and effectually seasoning wood, by exposing it to the influence of a rapid and continuous supply of hot air, so that it soon becomes thoroughly dry, appears to be satisfactorily proved. Longton’s method of seasoning, by extraction of the sap, is another way that is considered well worthy of notice. It consists in letting timber into vertical iron cylinders at the top, and the water being heated, and steam used to produce a partial vacuum, the sap, relieved from the atmospheric pressure, comes to the surface and is converted into vapour, passes through a pipe provided for that purpose.

Smoke drying in an open chimney, or the burning of furze, shavings, or straw, under the wood, gives it hardness and durability, and by rendering better, destroys and prevents woodworms; the heat of the gases alone has been known to kill the pests. In the manner stated, the wood is thoroughly seasoned, and Virgil seems to have been aware of its utility, when he wrote the passage which is thus translated by Dryden:

"Oft beeh, the pompous, and the sedge mole,"
"Or suffer linden, hardened by the smoke."

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

"Those long suspend where smoke their strength explore,"
"And season into use, and binds their force."

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

When timber is cut before the sap is perfectly set, it is bad, by reason of the worm which will certainly breed in the timber. Besides the common worm, to which timber in its dry state is more exposed, there are some others which are of a deciduous character, which commit their ravages on the timbering of sea works; of these, the most common are the pipe worm or teredo, a species of pholas, the cossi, and another mentioned by Solin, which is almost invisible. For the preservation of timber from the teredo, and other sea worms, various methods have been devised. Stockholm tar has been tried, but it is of little service, owing to its being manufactured from vegetable substances, and if exposed to the sea the salt acid of the water will eat it away in a very few weeks. Common gas or coal tar has likewise been tried with similar effect; and Kyan’s patent corrosive sublimate, or the bichloride of mercury, has been used, but has failed, as the substances used have been air-dried, and the pyroligne of iron, or pyrrolignite of iron must be of very pure quality, and the timber must be dry; afterwards the oil of tar should be applied, and not on any account should it contain a particle of ammonia. Mr. Pitchford, of Shoreham, has pressed this process in hydraulic works, with great success, and has disposed of the necessity of coating the piles with iron nails. It is exceedingly difficult to prescribe for the preservation of timber from the teredo; but one thing may be stated as certain, that present pyrrolignite of iron has superseded all the patents.

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

In the language of the general is, that worse than the teredo, or the entire ant tribe? Dry rot, which is to timber what consumption is to the human frame: once let it seize hold of a log, and you may send it to Madeira without any effect.

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

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

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

Fungi are not in some cases the primary cause of the decay of timber: they are not the disease, but the effects of it; and there is a small portion of unseasoned timber, when placed in a building, may generate the dry rot, and disseminate its baneful effects throughout the edifice into which it may have been unwarily introduced. Sometimes the dry rot is caused by a collection of putrescent matter adhering to the timber, caused by an adjacent vegetable corruption and a natural disposition of the timber to decomposition by the action of the putrescence, which it has been placed. When the parts of an edifice are so formed that the successive admission of pure air cannot take place, the exhalations from corrupted matter in the earth will collect upon the surface of the timber, affording a proper recipient for the seeds of fungi, and the growth of the fungus may be produced within it. Many instances of the propagation of fungi might be given, but as all are derived from the same cause, viz., vegetable corruption, it will be unnecessary to dwell longer upon them.

In a review, therefore, of the foregoing observations, it will appear that vegetable corruption is suitable to receive and germinate the seeds of fungi, and that such fungi are capable of absorbing the medullary particles of the wood, thereby wholly decomposing it; and that the timber itself, when confined or deposited in warm and moist situations before the motion of the particles is suspended, necessarily undergoes the fermentation which is attendant upon vegetables, by which nature effects the putrefaction. In another sense, the dry rot has become stagnant: decomposition and decay of the timber immediately commences. It is clear that, except when thoroughly free from moisture, or as it is called seasoned, painting must be as effectual a method as any for accelerating its decay. If wood is painted on one side only, it will last as long again as if painted on both sides.

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

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

Correction of Ships’ Compasses at Sea.—M. Fayé suggests to the Academy of Sciences at Paris, a method of determining at any time the compass of the ship. This consists of marking the ship’s log, which is usually modified as to inclines and form, a compass so arranged, that at any moment it may be stopped, and its direction thus registered. The log is towed in the wake of the ship, and at a sufficient distance to be out of reach of its magnetic influence, and when it has taken the true direction of the ship, which, if of proper shape, it will soon do, the compass is registered, hauled a board, and read. The proposition assumes importance, from the perpetual variation of the earth’s magnetic dip; but it has the apparent impossibility of perfect correction of compasses. In the course of his communication, M. Fayé records a curious experiment, which is worthy of repetition and study:—"Dissolve in an acid, soft iron devoid of any magnetic property, and then give force, and then give force, by a galva-panico process, in a thin film over the surface of a piece of copper, as is done in bating copper plates with iron, to give them greater endurance. This thin coating of iron, chemically pure, but hard and brittle, will possess so strong a coercive power, that I have heated a plate thus prepared to the melting point of copper without destroying the magnetism which I had before given it."
INSTITUTION OF CIVIL ENGINEERS.

President's Address.*

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

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

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

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

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

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

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

It is plain, therefore, that in every department of civil engineering the wants of commerce and society are pressing more and more urgently upon the resources of our profession. We have large seaways; but the Suez Canal throws them all into the shade. We have long tunnels through our English mountains; but we have now to penetrate the Alps. We have large bridges; but larger are required. We have noble ports; but they are choked with trade, and new accommodation of an improved kind is called for. We have steam ferries across rivers, estuaries, and straits, and rapid ocean vessels; but real and rapid transport is demanded. We have large warehouses, with convenient mechanical appliances; but large warehouses and better mechanical appliances have become a necessity. We have many thousands of miles of telegraphic communication; but nowhere is there a sufficient, and, in some instances, adequate solution of these problems, thus rapidly indicated, and in others which could be easily added, we may rest perfectly satisfied that the difficulties they present are not to be overcome by a stroke of genius or by a sudden happy thought, but they must be worked out patiently by the combination of true engineering principles, ripe experience, and sound judgment.

Having thus called your attention to the peculiar position of...
our profession in consequence of its rapid growth, and pointed out some of the problems which await an early solution, I shall now attempt to describe the nature of the functions of the modern civil engineer, and consider how the coming generation can be best prepared for its inevitable work, and to what extent this Institution can be made ancillary to that purpose. Although we know that our profession has been distinguished by great mechanical capacity, remarkable skill in working materials, profound science, and constructive knowledge, yet it is only during the present century that civil engineering can be considered to have become a distinct and recognised profession. Now, however, it has as

summarised that clause does fail. It is an art of immense merit and does not speak of it as a science. Many attempts have been made to define and describe a civil engineer in a few general words, but all such attempts have been more or less unsatisfactory. Still, though it is difficult, if not impossible, to describe an engineer by a short definition, it is not so difficult to enumerate and describe the nature of the works he is required to design and execute, and the professional duties he is called upon to perform. He has to design and prepare drawings, specifications, and estimates, and to superintend the carrying out of works which may be thus enumerated:—1. Railways, roads, canals, rivers, and all modes of internal communication preliminary to navigation; 2. Watercourses, levees, and all other works relating to the health and convenience of towns and cities; 3. The reclamation, drainage, and irrigation of large tracts of country; 4. Harbours of refuge and of commerce, docks, piers, and other branches of hydraulic engineering; 5. Works connected with large mines, quarries, ironworks, and other branches of mineral engineering; 6. Works on a large scale, connected with steam engines, with machinery, shipbuilding, and mechanical engineering. This list, which might be almost indefinitely extended, involves a vast variety of work, and must appear almost appalling to a young engineer, yet it greatly concerns his future success that he should, as far as possible, be prepared for any or all of the works embraced in the list. I believe the personal history of most of us would show that circumstances have led us in a widely different direction in the exercise of our profession from that which we originally contemplated, and that the success of many men may be distinctly traced to their ability to avail themselves of opportunities to advance in some new direction. The civil engineer must therefore be prepared for the various classes of constructive works thus enumerated: but in addition to this professional preparation it is of the first importance as affecting his true position, and the confidence which ought to be reposed in him, that he should have a thorough and complete knowledge of the objects of each work contemplated, as well as their true value, so that sound advice may be given as to the best means of attaining them; and he must be prepared, if necessary, to advise his employers that the objects which are sought are not commercially worth the cost of the means which would secure them. It is not the business of an engineer to add to his efficiency and value in any especial branch; in the same manner that a medical man will be more reliable in his practice on the ear and the ear if he possesses a sound practical and theoretical knowledge of every part of the human frame. All classes of the profession, but especially the railway, the dock and harbour, and the waterworks engineer, must possess a knowledge of parliamentary proceedings, so as to be able to avoid all non-compliances with the standing orders of parliament. This, it is true, is no easy task to acquire, but is in a great degree the natural consequence of a practical knowledge that neither engineers nor solicitors, nor the most experienced parliamentary agents, can understand what is intended. On the subject of parliamentary proceedings generally, it may be taken for granted that all committees desire to do justice to the cases which are brought before them, and that if an engineer fails to bring all the facts, and to state the interests of the public, or in arranging a fair settlement between antagonistic interests, it is not unfrequently due to the imperfect and crude manner in which cases are presented to them; and I would impress on all young engineers the importance, both to themselves and to their clients, of laying their cases before committees in the most perfect manner possible, accompanied by full and correct information, carefully prepared and clearly worked out.

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

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

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

The waterworks and drainage engineer must possess many of the qualifications of the railway and dock engineer, and especially those which concern earthwork and masonry; he must also be familiar with the means of obtaining information on the subject of rainfall in different localities, the methods of correctly gauging streams, and of ascertaining the proportion of the rainfall for his purposes after estimating for evaporation, waste, and the extent of the provision to be made for periods of dry weather, or for compensation to mill-owners and other interested parties. He must be conversant with the proper mode of operating the works of reservoirs, conduits, wells, tunnels, and aqueducts. He must understand, by the aid of the chemist and his own experience, the nature of the impurities in water, and the best mode of diminishing them, whether mechanically, by subsidence and filtration, or otherwise. To the waterworks engineer we must look for the solution of one of the great problems which the rapid increase of population is now forcing upon us; viz., a comprehensive plan of supplying each of the chief localities for the use of large cities and towns, and densely populated districts. We are completely outgrowing our present arrangements for water supply in the great majority of instances; and the convenience, comfort, and health of the public demand that such works when required shall be no longer postponed. The information and the improvement which have created the vast steam-ships of modern days. The ordinary timber-shipbuilder of old would have been literally "at sea" in the construction of modern vessels, wherein the material is iron, and when the size of the vessel requires scientific knowledge of form and resistance, of strains and of strength, and when steam is the motive power. The demand for large and swift vessels for ferries, for long voyages, for floating batteries, and for iron-clad sea-going vessels, has of late been so great that the construction of steam vessels.
has become a distinct branch of engineering, under the name of naval architecture.

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

I must not altogether omit a passing reference to the scientific talent which of late years has been devoted to artillery—its weapons of attack and works of defense; and I think we may fairly claim it is mainly due to some of the able members of this association that this art has made such vast improvements as have made it the scientific and mechanical art that it is at the present time. The question then arises, whether this branch of the profession has been actually created—artillery engineering.

ON THE TENACITY OF SOME FIBROUS SUBSTANCES.

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

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Dimensions</th>
<th>Tearing Load, lb.</th>
<th>Length of weight in feet</th>
<th>Tenacity in weight of feet, per pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast steel bar</td>
<td>1 in. × 1 in.</td>
<td>180,000</td>
<td>0.297</td>
<td>60,610</td>
</tr>
<tr>
<td>Charcoal iron wire</td>
<td>area 1 sq. in.</td>
<td>100,000</td>
<td>0.3</td>
<td>80,000</td>
</tr>
<tr>
<td>Iron wire, strong</td>
<td>girth 1.27 in.</td>
<td>60,000</td>
<td>0.8</td>
<td>75,000</td>
</tr>
<tr>
<td>Boiler plate, strong</td>
<td>area 1 sq. in.</td>
<td>50,000</td>
<td>0.8</td>
<td>60,000</td>
</tr>
<tr>
<td>Teak wood</td>
<td>1 in. × 1 in.</td>
<td>15,000</td>
<td>0.4</td>
<td>45,000</td>
</tr>
<tr>
<td>Deal</td>
<td>1 in. × 1 in.</td>
<td>12,000</td>
<td>0.4</td>
<td>33,333</td>
</tr>
<tr>
<td>Hemp rope, hawser</td>
<td>girth 1 in.</td>
<td>1,050</td>
<td>28</td>
<td>37,105</td>
</tr>
<tr>
<td>Dito, cable-laid</td>
<td>girth 10 in.</td>
<td>67,200</td>
<td>0.279</td>
<td>15,700</td>
</tr>
</tbody>
</table>

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

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

R e a l Y o w n C e n t r a l

<table>
<thead>
<tr>
<th>Tenacity of warp in linear feet of canvas</th>
<th>Tenacity of web in linear feet of canvas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenacity of warp in linear feet of canvas</td>
<td>32,552</td>
</tr>
<tr>
<td>Mean tenacity of the flaxen yarn in linear feet of itself, being the sum of the tenacities of the warp and web</td>
<td>30,788</td>
</tr>
</tbody>
</table>

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

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

The flaxen thread was unbleached, and measured 15,833 feet to the pound weight. Its tenacity was not uniform in different parts; and as, in the practical use of any material, the least strength alone is to be relied on, I ascertained carefully the breaking load of the weakest parts of the thread, which was 6 lb. Hence the tenacity of that thread, in feet of itself, was 15,833 × 6 = 95,000 feet.

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

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

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

Knowing that silk fibre is of the same heaviness with water, so that a prism a foot long and an inch square weighs 0.433 lb., it is easily computed that the tenacities of the two specimens in lb. on the square inch are as follows:—Thicker, 49,000, very near copper wire, 51,000; thinner, 13,600, quite inferior to plate.

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

A load of 6 lb. put upon a thread of the thicker kind, whose original length was 5278 inches, produced a total extension of 396 inches, of which, between 1'5 and 1'8 inch, was set, continuing when the load was taken off, but gradually diminishing after that; the amount of this strain is 12 per cent. of the whole. The modulus of elasticity of silken fibre is therefore 3,400,000 lb. on the square inch. If we take the proof load, or greatest safe load, at one-third of the breaking load, or two-thirds of the boiler plate of bearing shocks, which is a third proportional to the modulus of elasticity and the proof strength, is found to be as follows, for the thicker specimen of silken thread:—473 feet (that is, 473 feet-pounds for a prism weighing 2 lb.), corresponding to 205 foot-pounds for a prism of 1 inch square.

The tenacity of a 2 inch square, and 1 inch in square, has the following values for some other substances:

<table>
<thead>
<tr>
<th>Material</th>
<th>Tenacity in weight of feet, per pound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very strong tough steel</td>
<td>...</td>
</tr>
<tr>
<td>Strong hard steel</td>
<td>...</td>
</tr>
<tr>
<td>Soft steel</td>
<td>...</td>
</tr>
<tr>
<td>Good iron wire</td>
<td>...</td>
</tr>
<tr>
<td>Good bar iron</td>
<td>...</td>
</tr>
<tr>
<td>Strong plate iron</td>
<td>...</td>
</tr>
<tr>
<td>Strong tough cast iron</td>
<td>...</td>
</tr>
</tbody>
</table>

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

Steam Fire Engine.—A trial of a very powerful Steam Fire Engine, stated to be the most powerful one of the kind ever constructed, took place on the 29th ult. The engine tried was the sister engine to the "Sutherland," built by Merryweather and Sons, and proved herself to be even more powerful than her celebrated predecessor—throwing a jet of 1½ inch diameter, in the direction of a moderate wind, to a distance of 200 feet—the spray going much farther. Under similar circumstances, a 2 inch jet was projected over 200 feet.
EXPANSION AND PROPULSION.

All persons are familiar with the transcendent achievements of steam power, and almost all consider them prelusive to others still greater; but while everyone sees what it does, comparatively few perceive how it is done. Ideas of it that reach no farther than external features and movements of an engine are inadequate, and may be cloudy and chaotic. Even with engineers themselves, there are points on the evolution, treatment, action, and applications of the fluid far from being lucid and sharply defined. Opinions greatly vary. Two examples may here be quoted—one of marked interest to the engineering community, the other of gross importance to naval architects and marine engineers.

1. The economy of expansion by cut-offs. 2. The virtue of forms in propelling blades.

The competing engines of the Algonquin and Winooski will go far to settle the first, but not the second, without removing the undershot water-wheels, suspended as paddles over the sides of both vessels.

The economy of stopping the flow of steam into a cylinder before the piston reaches its ends, there is and has been no diversity of opinions; the fact is palpable, and such has been the uniform practice since the beginning. The points in dispute are the extent to which the principle is urged, and the amounts of gain claimed. Prevailing opinions, right or wrong, have always been derived from school for other than theoretical and demonstrative is still yielded to popular dogmas, to interest and feeling. Inventors, of course, build without data with them, and what is worse, their propositions are too commonly made bases of speculation. All this is natural, at any rate unavoidable; nor is it the whole, to be regretted that truth in mechanical as in other science is not readily accepted. The difficulty is not from a confluence of interests and error. Without efforts to attain it we could neither be prepared to receive it, nor capable of appreciating it. That which costs little or nothing is held of small account.

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

It would moreover be a marvel if additional power could be got out of a definite quantity of steam by increasing its tension—if one-third of a charge at 90 lb. on the inch were more effective than a full one at 30 lb. As well expect to spin more thread out of closely than loosely packed cotton. Compression can add nothing to the fibre of the solid, and therefore the economy in expanding the fluid, rather than to an increase of its quantity, and engineers on both sides of the Atlantic have inured to the system. The government experiments will, it is presumed, definitely settle the question. When they are completed and published we shall learn whether the principle of high expansion and high stroke (7 feet of steam to stroke of expansion of one wheel's blades) at each revolution: some wheels actually lost 12 feet of stroke at every turn. But there were engineers then who maintained the hypothesis, "the heavier and thicker the blades the better, for the heavier the wheels the easier they work." Their length of paddle planks then varied from 12 and 14 to 22 feet! The incessant jar arising from their striking the water...
was shown to be a ceaseless source of destruction to both engine and vessel, as well as waste of power. Some boats had houses wider than their decks, so as to make it doubtful to strangers to such craft whether the hulls were accessories to them or they to the hulls. In this respect the number of bales has been greatly reduced. There were then steamers with 36. The United States, among others, had one belted to each side of her engines. The full consignment settled down to 25, next to 14, and now there are examples of only 7 being employed, as urged in the report. But the most important suggestion is yet ignored by those who have taken advantage of the rest, and, with scarcely an exception, without the slightest acknowledgment. It will, however, yet be conceded that the naked arms of old men would, if sufficiently lengthened, compel them more effectually than the usual planked paddles attached, because of their approximating to the only principle applicable to the case—that which nature illustrates in the long, narrow, and tapered organs of her swiftest swimmers and flyers; and (as there is no originating a law or principle of our own) which, in order to success, may be first practiced and fall as heretofore. Instead of churning the water’s surface with wide dashers, we must take deep hold of it with blades that enter without jarring and lift no loads of it on leaving.

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

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

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

In 1855, Prof. Bache and Henry, in a letter to the Secretary of the Navy, stated that the proposed experiments “would be of great practical value to the world at large, and of particular advantage to the Navy of the United States.” But the time for them had not come. The reply was, “The Department appreciates very highly the importance of a series of experiments on the best form of propelling blades or paddles for producing, with a given expense of power, the greatest useful effect. It has, however, to regret the want of authority to undertake them, and could not, without inconvenience to the public service, furnish the means of carrying them into effect.” It may be that the Navy Department inclines to the opinion of some of its subordinates, that the paddle wheel is all that is wanted, and, so far from ever being superseded, is destined to move the earth’s fleets of steamers as long as its prototypes transpire from running streams to miles and oceans. Well, why not then have a practical demonstration of its superiority, which would repay the cost a thousand-fold, and reflect enduring honour on the department. The expense can hardly exceed the tithe of a tithe of the pending experiments on steamers and steam. Were it as great, it would be true economy to incur it.

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

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

SOCIETY OF ENGINEERS.

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

It is not necessary that I enlarge here upon the pet project nor upon the probable future of the engineering profession, nor shall I detain you with a few of the engineering works achieved last year, nor with a list of what is to be done this year.

All these are in the habit of reading in the newspapers, and I need only say, if it be considered necessary in my position to say it, that I believe the profession of engineering is now established upon a footing which will ensure the success of everyone who adopts it and practices it rightly and well.

What, I think, should be particularly addressed to the members of this society on an occasion like this, are some remarks upon the possible development and probable future of the society itself. It is now in its eleventh year, and it already counts a large number of members, and is in receipt of a considerable amount of annual income. So far as I can remember, we have been exceptiionally fortunate in having enjoyed the benefit of the unceasing labours of our honorary secretary, Mr. Williams, and for his services, exerted in every manner that could secure the best interests of this society, it might, I am inclined to believe, have fallen to the ground long ago. I say this quite apart from any complimentary considerations, and merely because it must enter into our estimate of the future position of the society. We occupy, as a society, a somewhat exceptional position. Only a small proportion of our number are engaged in the design and conduct of engineering works upon their own account. I am glad, however, to see that our numbers are now being regularly recruited by the industrial practice.

The value of a society like this is in its power of concentrating professional talent, in influencing it in new directions, and in securing public respect and confidence. Now this can be done only by deserving both. Unless it can be seen that successfully executed works are described here and discussed by those who are competent to do so, we cannot expect to take the rank which, as a society, we all wish to have before the world.

We have had here many papers, exhibiting much industry in their preparation, papers containing unexceptionable truths, yet these papers have been, in many cases, compilations, instead of being prepared from the special knowledge of their authors. Not but the society is under obligations to whoever presents a paper which is not in itself unsound. Members should dismiss from their minds any idea that they are doing a favour to the society in preparing papers for reading and discussion. Not but what the society may and probably does derive some benefit from them, but they should be prepared from a sense of duty, and as but a fair contribution towards the interest and usefulness of the proceedings. Those who will take the trouble to put upon paper any subject which they really understand, cannot fail, too, to derive some advantage from doing so. The preparation of papers disciplines the mind, and compels the writer to choose his forms of expression. A facility for this kind of composition, whether natural, or acquired as it may be by practice, is of great value in every sphere of professional life.

The ability to give correct expression to sound truths and to good ideas often enables the speaker or writer to influence those who would be otherwise far out of his reach, and thus not only to derive direct advanages for himself, but to advance whatever
proper cause he may make the subject of his communication. In this light the preparation of papers by members of this society is to be regarded as a valuable exercise, and for the sake of the writers themselves it should be followed whenever time and a good subject can be found. This preparation compels the writer to study and to reflect, and is in many ways an excellent means of self-improvement.

I have endeavoured to point out is the one which, along with some other circumstances, has brought the parent society, the Institution of Civil Engineers, to its present high position. It might, indeed, be asked why a further society like ours should be needed at all, but I believe that our meetings furnish additional and valuable opportunities, more especially for the young engineer, than the Institution, which they途径 the Institution, which they

neither hardy afford so well as this society. However we may secure the co-operation of gentlemen in actual practice as engineers, we shall always be represented, upon the whole, by a much younger class of men than those forming the Institution.

And our subjects for discussion will also embrace more works mechanical engineering, and it may, indeed, be said, that ours is the only professional body in London which habitually does deal with mechanical engineering. Our meetings give opportunities for the expression of opinions, and for practice in discussion, which could not be expected, at least by the younger members, at the larger and more public discussion meetings. That, properly conducted in the future, the Society of Engineers will have no need to fear that its position will not be duly recognised and the value of its proceedings acknowledged by the profession. Any idea of rivalry with the parent society, as we may call the Institution, can never, I feel sure, have been entertained for a moment by anyone amongst us.

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

In looking at us upon the works which are already in progress, and in looking forward to those upon which the younger members are likely yet to be engaged, we cannot fail to be struck with the increasing improvement offered in the improvement of our engineering works in hand; —never before have so many new works been contemplated. Improved machinery and improved processes are so chiefling almost every kind of production, in the getting and coal, in the working of metallic, in the manufacture of bricks, glass, paper, etc., and in the communication, that we are adding to our national capital faster than ever before. It is impossible, indeed, to define the limits within which invention, as applied by civil and mechanical engineers—for, whether they are inventors themselves or not, inventive are the best fitted to carry most inventions into practice—implied is now adding to the permanent wealth of the nation. What the steam engine, the spinning frame, the power loom, and the iron rolling mill have done for Great Britain is really beyond our powers of estimation. Then came a later series of inventions of not less importance—gas-lighting, the locomotive engine, the steam printing of the oldest, ocean steam navigation, and the electric telegraph. Still later we have had the reaping machine, the steam plough, and the Bessemer process. Each and all of these has done, is doing, and will in future time continue to do, more for the good of mankind than was accomplished by all the art and skill of the two thousand years of the world's history previous to the time of Watts, excepting only the invention of printing and the discovery of the miner's compass. It is engineers who are turning all these grand inventions to practical account for the benefit of all the world. In many cases engineers are themselves the inventors of new processes and machinery. A great secret of professional success consists in knowing how to improve upon previous practice, whether by invention off-hand, or, more commonly, by that course of elaborate thought and comparison which results in what the engineer prefers to call the improved design. The latter is indispensable to success, but when controlled and regulated by good knowledge and sound judgment it is a great aid.

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

The National Boiler Insurance Company.

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

Mr. Hilles commenced by stating that the company had already acquired an extensive and rapidly increasing connection amongst boiler owners in the districts to which its operations have been extended, and the prospects for the future are of the most promising and encouraging character. No explosion has occurred with any boiler within this year, and the boilers have been injured through mistake or negligence of the attendants, and other cases have been reported where serious injury would have been sustained had the boilers been unprovided with good fusible plugs on the furnace crown, which, by their timely action, prevented damage. One case of partial collapse of the furnace tube has been reported, but this may all hope that the Society of Engineers, as an establishment or an institution, may in future be enabled to render greater services in the advancement of engineering knowledge than ever before.

The boiler was fed with water strongly impregnated with salt and
chalyke matter, which, owing to omission of frequent cleaning, was so thickly deposited on the furnace crown as to cause overheating of the plate, and consequent injury. The use of good surface blow-out apparatus would have prevented such an injury. Many serious defects, some of them of a most dangerous character, have been met with in the boilers inspected. Internal corrosion is frequently met with, in some cases seriously weakening the boiler in a very short period. In most cases its progress may be arrested by the daily admixture of a small quantity of soda and 1% of soda with the feed-water. In any case where the use of soda does not prove effective he would suggest that the water should be analysed by a first-class chemist, who would doubtless be able to recommend an antidote. Many of the leading boiler makers now rivet on the boilers suitable joint-beds for the fittings, and good mouthpieces, with plated joint faces, at the mudholes, which should facilitate the proper making of the joints and materially strengthen the boiler. Where these beds are properly attached, and the joints thereto carefully made, leakage is avoided, and much trouble and expense saved to the owners. Many glass gauges were met with, where the handles of the pipes were broken and in other cases the taps were so leaky that the gauge could not be properly tested; others were so dirty that the height of the water was scarcely distinguishable. Many instances of the consequence of neglect of the water gauges have been recorded. In one case a two-fired boiler was fitted with a glass gauge and a float gauge, but the former was not kept in order, and the float only once observed. The result was that the furnace crown was seriously injured through deficiency of water. He did not consider ordinary float gauges sufficiently sensitive for use on internally-fired boilers, and would strongly advise that where attached to those externally-fired there should be two gauges to each boiler, as a check on each other. Several cases have been reported where the glass gauges had been neglected so long, that the furnace crown would be actually bare of water when several inches were visible in the glass. These were certainly proofs of gross carelessness or ignorance on the part of those who fitted the boilers. As an instance of the gross negligence which is occasionally displayed by boiler-rendents, he mentioned the following:—An externally-fired boiler, fitted with a “float-whistle gauge,” was found with the water so low, that it was out of the range of the float, which the inspector found was scotched fast, to prevent its indicating the deficiency.

Many safety valves have been found defective from various causes, and he was sorry to remark that, despite the fact that this has been written at various times on the subject, and the numerous disasters which have occurred through their abuse, many instances of overloading with irregular weights of various kinds and other defects have been reported. In one instance where the safety valve was loaded to 40 lb. per square inch, the pressure gauge indicated 28 lb., when the valve was blowing off, the valve had in consequence been overloaded with pieces of iron to blow off with the gauge, thus seriously increasing the pressure; and the mistake was not discovered until the gauge was checked with a correct indicator, which showed it 14 lb. per square inch below the actual pressure. Fortunately, the boiler was amply strong for the pressure at which it was usually worked.

The safety valves of some of the boilers proposed for insurance were found on inspection to be loaded to above double the proposed pressure, of which the owners were quite unaware, until the boilers were inspected by the officers of this company. Compound safety valves, which discharge the steam when the water sinks to the proper level, and act as safety valves, are a useful fitting, especially when attached to single boilers. The defects to which gauges are liable is exemplified in the remarks on safety valves. Some of the gauges noted were found seriously inaccurate; in one instance, the gauge indicated the actual level, and the actual blow-out pressure was 40 lb. per square inch. Mr. Hiller states that the great superiority of Smith’s fusible plug has been fully sustained by the experience of the past year, and confirms the confidence placed in it by this company, in making the reduction of 10 per cent. from the premium of insurance of those boilers to which it is attached.

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

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

The exploded boilers were of the following descriptions:—One or two fixed internally-fired, 14; locomotives, 11; cylindrical externally-fired, 13; iron furnace boilers, 5; portable (hydraulic type), 2; vertical externally-fired, 2; marine ditto, 2; balloon or haystack, 2; other descriptions, 3; total, 53.

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

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

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

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

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

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

By JAMES ROBERTSON.

(With an Engraving.)

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

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

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

The mechanical properties possessed by these screw motions, as distinguished from the ordinary screw, are chiefly the properties of indefinite variation, or change of thread, or pitch of screw, producible in one screw, any pitch being readily obtained from an infinitesimally small pitch, to direct rectilinear motion on end; or changing the thread right or left by changing the direction of the motion of the nut or screw; the mechanism which constitutes the nut being in most cases easily adapted to do this.

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

The primary principle of these motions will be understood by Fig. 3, consisting of a cylinder mounted on an axis, and placed on bearings so as to be free to move on end, and to revolve freely, representing thereby the screw, and having placed in effective driving contact with it a parallel frictional pulley of sufficient breadth to withstand wear, keyed on an axis, and held in position by a forked holder having a lever fixed in the fork so as the axis of the frictional driving pulley is kept horizontal to the plane of the screw barrel, but may have its axis set by the lever, shown at right angles, or at any intermediate angle with the axis of the screw barrel, thereby representing the nut. Motion being communicated to this pulley by the belt pulley and strap shown, and communicating motion by its contact with the frictional screw, causes it to revolve; and, on the lever and axis nut pulley being held at an angle to the axis of the screw barrel, a screwing action at a corresponding angle, as indicated by the dotted helix line on drawing, is produced; and when the screw pulley is turned round to a corresponding angle in the opposite direction, a reverse or left-hand screw motion will be described as indicated by the left-hand screw dotted helix line in barrel; and any intermediate screwing motion, in either direction, can be described without changing the direction of the motion of the nut or screw, from a screw of an infinitesimally small pitch of thread up to direct rectilinear motion on ends.

Figs. 4 and 5 are elevation and section of simple frictional motions; Fig. 3 showing a nut composed of two frictional pulleys, placed at opposite sides of the screw barrel, in which position the contact pressure on the axis of the barrel is neutralised, and double the effective contact thereby obtained.

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

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

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

The nut rolls, T, U, and V, have their diameters enlarged at each end, and portions of the enlarged parts turned slightly conical on the inside edge, seen in section in Fig. 4, so as to form the part of the roller shown in Fig. 5, p, q. The roller U, is moveable on end, and is drawn on the internal inclined edges m and n, of the barrel S, so as to tighten itself in between the screw barrel B, and the internal surface of the barrel S. By thus tightening up the one roller U, it also tightens up the other two rollers T and V, giving any required amount of bite without causing other than a rolling friction, which is very slight.

To keep the rolls in the required angular position, a guide piece, W, W, W, with the notches O, P, and Q, in the upper flanged part for guiding the necks of the rolls, seen in Fig. 5, and three sets in Fig. 4, at t, r, and u, are provided, the notches put out for the necks at each end of the roll, and placed obliquely to each other, to give them severally a corresponding angular position. The neck t, has upon it a tubular gland-piece, which communicates the pressure of the screw nut to the enlarged moveable part of the roller L.
On the hoop S being made fast, and the screw barrel R made to revolve by the guide pieces N, as described, move round with the rolls at a red hot motion, and as it moves in contact with both the screw barrel R, and the pressure hoop S, it moves round freely, as all the pressure exerted on the bearings formed in it for the roll necks is only such as is caused by its own weight, its action being simply to preserve the rolls in their due position.

Nutation can be given to the pair of rolls formed for straightening bars of an elastic nature in a cold state, in connection with Figs. 6 and 7. The roll Q, Fig. 8, is formed with its surface hollow, in the direction of its length, and the roll R, opposite it made correspondingly rounded, so as to make the surface hollow, between them of equal width, and curved when apart, and to fit the surface of the bar between them. So formed, it is subjected to continuous bending, and at every point through its length, so that elastic bars of iron, steel, or any other substance possessing elasticity, can be bent to the limits of the curve from which it recoils, and thereby, when a crooked or bent rod is passed through them, the parts that are high before will come down to the same distance from which they recoil, and consequently they will pass from the rolls straight. Any bar possessing a moderate degree of elasticity can be straightened cold in this way, and without requiring much power, as the surface of the rolls can have a greater curve given to them than is necessary, so that the bar does not require to be bent between them to this double purpose or nature, after a slight study, will be found quite characteristic of this principle of mechanical action.

The first set of these rolls of a large size was constructed for the Barrowfield Works, of Messrs. R. Liddiard & Son; and afterwards a large set for the Glasgow Iron Co.’s Works at Motherwell, where they are straightening and forming a cold state up to 6½ inches diameter, and which have now been several years in operation. There are other two sets in the neighbourhood of Glasgow used for straightening lap welded tubes of from ⅜ inch up to 8 inches diameter. Those at the Works of Messrs. A. & J. Stewart, of St. Enoch-lane and Cordiner, being the first used for this purpose, and subsequently a larger set by Messrs. Eadie and Spencer, of London-street. Other sets for England and abroad, made for similar purposes, and of late somewhat more in demand.

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

The rolls are set apart with the aid of the rolls, the coupling bosses G and F, extending beyond the cheeks, have angular working boss couplings placed on them, and the driving shafts coupled with them for communicating motion to the rolls. The bearings of the roll necks are placed in the cheeks to give the axis of each roll an inclined position, and in opposite directions to each other, and the larger sizes proportionately, as it passes through the most suitable inclination. The rolls for iron bars and tubes is carbon for forming softer materials, where greater speed might be desirable, a greater angle could be used. The surface of the rolls have to be formed slightly hollow in the direction of their length, to form a parallel space between them for the bar; and for some purposes can be bevelled out at the entering end with advantage.

The position of the supporting bar B, and the bar placed in the rolls, will be seen in Fig. 7, the end of the supporting piece being shown at the centre of the bar O. This adjustable anvil piece or bar is secured in any position required for the various sizes of bars; the smaller sizes requiring the steelied edge of the bar to be used, as it is being set, and the larger sizes set farther from it. On the screws, J and K, being adjusted to take sufficient hold of the bar to be straightened, motion is given to the rolls in the direction indicated by the arrows b and m, and the bar is made to revolve in the opposite direction; while it is thus made to revolve, the angular position of the rolls causes it to move to the end in the direction indicated by the arrow s. The motion of the bar or tube is straightened by short, equal parts of a revolution, as it passes through the rolls.
ing flanges bevelled from the inside, acts on the bevelled edges of the ring in the manner of a wedge and groove pair of frictional wheels. The pulley F, is supported in bearings formed in the swirling fork G, which is placed upon a stud pin H, similar to that described in connection with Figs. 1, 2, and 3. A handle I, is fixed on the fork, by means of which the fork G, and with it the pulley F, and speed ring D, are moved round to any screwing angle that may be required.

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

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

In answer to questions relating to the action of the arrangement shown, as in Figs. 9 and 10, Mr. Robertson said that the speed ring D, was not held by pressure in any part of it, but the driving frictional contact of the ring on the barrel was produced by the twist of the belt, and the driving action thus obtained was as great as if the pulley were passed over the barrel itself. Its motion on end was reversed by the handle being turned to an opposite angle, as indicated on the drawing. The power or driving action obtained was the question of power to hold the surfaces together, taken one of every surface. The screwing speed was regulated by the angle at which the speed ring was held. Any pitch of screw was readily obtained from an infinitesimally small pitch up to about one of one inch pitch.

Mr. D. M. Donald saw this motion of the production working. The only thing in this application of it he would regard as objectionable was the angle at which it required to be held to produce the screwing action.

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

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

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

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

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

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

Mr. Robertson said that the intensity of the force exerted on end would be great or small in proportion to the pressure given to hold the surfaces of the rolls in contact, and which was easily regulated. In boring, suppose the pressure given was just enough for the tool to stand, the action would be as described by Mr. Gale. In one instance, at the Glasgow Iron Works, he had seen the passage of the bar being straightened accidentally obstructed by another bar being left lying in its way, and indications were given of enormous power. He should say that in straightening round bars of 4 inches diameter, the force on end would range from 10 to 20 tons.

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

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

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

MATERIALS MOST APPROPRIATE FOR LONDON EXTERIORS.

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

(Continued from page 5.)

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

The latter subject is considered in the present paper, by referring to some of the most important producing the subject of constructive materials. Wood was at one time used wholly in London buildings, now it is almost wholly abandoned in external construction. The Building Act contains no clause forbidding its use in bressumsers, storey posts, and shop fronts nor indeed in any way provided it is set back 4 inches from the external face of the wall. It is now an acknowledged fact, that in case of fire, wood is a safer and stronger material than iron, and its resistance to the weather, so long as it is preserved by paint or otherwise, requires no argument. It readily admits of carving and other ornament, and bears a treatment peculiar to itself, which gives at once a domesticity which cannot be equalled by any other material. Frequently the judicious design of a shop-front and the windows of the upper stories, will give great character to an otherwise plain building. It can be employed with the greatest ease and readiness, but the chief disadvantage is the cost of triennial painting.

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

In no material is the want of a distinctive treatment more felt than in cement. No other has been more abused, and no other has been applied to such base purposes. When it is used as a coating to cover a multitude of imperfections in bad building, or so applied ornamentally as to lead people into the belief of being another material, no words can be strong enough to convince the case. In so many kinds and qualities of cements manufactured, but that known as Portland has the character for standing the best, and certainly has the best colour. The chief requirements in its manufacture are, that the ingredients are well and properly mixed, thoroughly burned, and ground to powder. Care is required in working that its sets proceed uniformly and that there is no sudden variation in strength. Care is necessary for even the panel, the mosaic, the brick, and panels and flat surfaces generally. Incised ornament seems most applicable, and the introduction of a coloured cement ornament, in a Portland cement ground, would be effective, if some preservative process could ensure discoloration, patens
for which have been obtained, but are not in general use. As a rule, applied ornament in cement should be rejected, as much of that now in existence will sooner or later lose its key, and fall by its own weight. A painful instance of this occurred recently in the Stowe.

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

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

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

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

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

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

The decoration of a building with majolica panels, friezes, pilasters, &c., and encaustic tiles, is well worthy the attention of an architect, as by their use he may obtain an immeasurable material. The chief objection however is, that having no other fixing than cement, the weather can easily find its way through the joints, and in course of time destroy the key. Mr. Digby Wyatt, at a recent meeting, suggested the formation of a small eye at the back of the tile or plate, to receive a hook of wire or other material, to be inserted into the brickwork, so that no danger might be apprehended in their use in external doors for any period of time. If used in a panel, an iron, slate, or wood bead, or moulding, might be fixed, to form a stop. Machinery has lately been used in the production of encaustic tiles, the benefit of which is apparent from the fact, that the tiles of two colours may be produced at a cost of 13d. each. Although at present in its infancy, enough has been accomplished to show that encaustic tiles may be as cheap and plentiful as common bricks, and, on account of the increasing love of colour and ornament, will sooner or later take the place of cement. The process of manufacture is exceedingly simple, and any design that may be desired can be worked out at a very much smaller expense.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Although not possessing the richer materials abounding in other countries, there are few that offer to the architect so great a variety of building materials as our own highly-favoured land.

From such he can make his own selection, and, in so doing, should give the preference to those which will effectually resist the London atmosphere, so that his buildings may retain their character and colour long after they have passed out of his hands, and become the builder and architect’s permanent works.

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

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

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

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

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

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

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

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

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

Introductory Remarks.

Electricity is, unquestionably, the most extraordinary law or force of nature. It exhibits its presence everywhere and in everything by the effects it produces; we see the effects in the air, the sea, and in the more solid materials of the earth; and, although we cannot see the force itself, we weigh it as if it were in the balance. We can produce its effects by simple friction or by change of temperature, by chemical action, or by the motion of magnetic bodies. We can produce artificial currents for short or long periods, perhaps for any duration of time; already they have been in constant and uniform action for upwards of twenty years, and have performed the duty assigned to them. We have, however, been unable to imagine that all the effects of this most subtle force have been discovered; it is more probable that it silently produces in nature many effects which are not observable by our senses, or at least have not yet been discovered. But, be that as it may, the effects which we have already become acquainted with have led to many important results, and are still leading onward to greater achievements; and of all the purposes to which this force has been applied the telegraph seems to be the most wonderful. It is now capable of conveying our thoughts hundreds of miles faster than we can think them, and many times faster than we can write them. In doing this it will travel overland through conductors and back again by similar paths, or it will travel out by the earth or sea and return through other conductors, or it will travel out by conductors and return by the earth or sea. It will print our thoughts on paper in common type, or it will merely exhibit them to the eye. It will write autograph letters hundreds of miles away, and it will draw our attention by audible sounds. It will tell seamen at our seaports the exact Greenwich time to less than a second by the falling of a bell, whereby they may regulate their chronometers without leaving their ships. By it we can regulate all the clocks in a town, or even work them throughout the whole kingdom, or find the longitude of places with far greater accuracy than before. It can convey letters from earth to earth; and it will tell the mariner the instant the lead touches the bottom. It can work the machinery of our lighthouses and produce the light at the same time, besides many more purposes of utility too numerous to be described here.

Of all the effects produced by this force, magnetism has hitherto been the most extensively used for telegraphy. This seems to have arisen from the fact of its being more easily applied, and for some special purposes it is unquestionably the best; for instance, for the purpose of working the traffic of railways, where but few signals are necessary to be transmitted at one time, or between establishments at moderate distances, where but few wires are required; or it can work the bell of a watch by the pressure of the finger, or even by the body of the watch. But in all other cases, it is the principle of the electromagnet which is employed. It can be used in the form of an iron core which attracts a piece of iron when a current passes through it, and repels it when no current passes through it. In this case, the current is produced by the movement of the iron core, which is connected with a number of insulated wires, and the wire which is to be operated upon is connected with one of these insulated wires. This system is much more efficient than the former, because it does not require a separate current for each wire, but only one current for all the wires.

Automatic Telegraphy.

Automatic telegraphy consists of methods of transmitting and receiving previously-composed messages between distant places by means of self-acting machinery in connection with electric circuits, and where properly carried out, it is distinguished from common telegraphy by the great celerity with which messages can be sent and received, as well as by the great accuracy it enables in the transmission and reception of intelligence. Indeed, the telegraphy of the future offers far greater advantages than the present, and the progress of which we are already conscious is so vast, that he has devoted to it much thought, time, and labour. He was induced to do so from the following reasons, viz., seeing that the action of the human hand, however expert, could never take a title of the advantage of the speed of electricity, and also that the use of numerous wires was very objectionable, in consequence of the increased danger of being cut off and being in danger of being cut off and difficulty of obtaining good insulation among many wires of great length. At the time he first turned his attention to the subject of electric telegraphy, several wires were used for each pair of instruments, and never less than three; in consequence of which he endeavoured to contrive methods for reducing the number of wires. This was soon accomplished, and now it is possible of working on a single circuit, and afterwards succeeded in working with a single wire, having discovered that the earth might be used with great advantage for one-half of the telegraphic circuit. As this property of the earth is unquestionably a most extraordinary phenomenon, and still remains a paradox even to the most ingenious of scientific men, and yet, it has been carefully acted on in this country, and has been used by M. Steinheil, in 1838, but, from some cause or other, it obtained little publicity; nor does the author appear to have exerted himself to remove the reasonable prejudice with which so singular a paradox was naturally received. A most ingenious gentleman, Mr. Bain, established a most important principle, and proclaimed its application somewhat later; and in 1843, perhaps the first convincing experiments were made by M. Matteucci, at Pisa.

Again, Lardner observes that, "of all the miracles of science surely this is the most marvelous. A stream of electric fluid has its source in the cells of the Central Electric Telegraph Office at Liverpool, and then passes to London, a distance of 200 miles. From London it goes to the coast of the Channel, and returns to Liverpool, where it is then divided into two streams, one of which passes to Manchester, and the other to Liverpool. In this way, the fluid is conveyed from one point to another, over a distance of 800 miles, in less than an hour."

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

Although the automatic system has met with much opposition and neglect for a period of nearly twenty years, the writer thinks that it is now fast approaching a period when the great advantages of the public will compel its general adoption; indeed, this necessity is partially shown by the number of telegraph inventors who have brought forward machines on the same principle during late years; but it is more clearly shown by the large scale of the London and Edinburgh telegraph, which is constantly increasing, and which is now in operation in many parts of the country. The establishment of a telegraph office at each town and village is a continual unnecessary expense to keep in order; but, setting the matter of cost aside, let us look at the working effect. It is well known that in damp and foggy weather, however well insulated the wires may be, small portions of the electric fluid will escape, from wire to wire, at all the points of suspension, and often from one to all on the same line of posts, especia  

* Read before the Society of Arts.
longer and shorter wires, causing confusion among the instruments, and this confusion is greatly increased when many instruments are working at the same time.

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

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

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

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

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

Electro-magnetism, it is true, would answer to some extent, but no such ponderable body existed, to be moved with great rapidity by the electro-motive force. So among telegraphic lines, the force being small, all the mechanical actions produced by it must be of necessity very delicate, and require fine and delicate adjustments, which have to be often varied with the varying strength of the currents. Besides, delicate mechanical actions are too liable to get out of order, and after much thought, and numerous experiments with the magnetic as well as the chemical effects of electricity, the writer decided to use the latter only for his automatic system, as the currents would have nothing to perform but decomposition at the point of the chemical pen, the machinery being worked by other power.

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

If the paper be moved under the style while the current flows, a continuous line will be traced upon the paper. If while the paper is thus moved the current is permitted to flow only during intervals of long or short duration, the paper will be marked with lines long or short, according to the intervals during which the current was flowing; there being no mark made during the suspension of the current. The long or short lines thus traced upon the paper will be separated one from another by spaces more or less wide, according to the lengths of the intervals of suspension of the currents. It is evident that the same effects will be produced, whether the style be at rest and the paper moved under it, or the paper be at rest and the style moved over it. The paper may be moved under the style by various mechanical expedients. It may be in the form of a ribbon coiled upon a roller, and drawn under the style, which was one of the writer's first plans; or it may be in the form of a common square sheet, and wound upon a cylinder, to which could be given a revolving motion at the same time as the suspension of the current in the direction of its axis, so that the course of the style upon it would be that of the thread of a screw or helix; this was also one of the plans the writer adopted in his early experiments, but the plan he has found most convenient in practice is to cut the paper into a form of circular discs, about 16 or 20 inches diameter, and after being chemically prepared, are laid upon a metallic disc of equal size. To this disc is given a motion of revolution round its centre, in its own plane, by clockwork, or any other convenient power, while the style receives a slow motion directed from the centre of the disc towards its edge. In this case the style traces a spiral curve upon the paper, winding round it continually, and at the same time revolving constantly but slowly from its centre towards its edge.

Punching Machine.

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

**Transmitting Apparatus.**

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

**Receiving Apparatus.**

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

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

The author purposes to have only two wires at most on one line of posts, one to be called the up wire and the other the down wire, so that messages can be transmitted in both directions at the same time. The messages are transmitted by the apparatus through the main wire in the manner shown at Fig. 3, but his experience has shown him that the best way to receive the messages is through branch circuits, so as to keep the main wire contacts always complete, except in the process of transmission. Figs. 4, 5, 6, represent three different stations on a telegraph line. A represents a galvanic battery, C the transmitting apparatus, and D the receiving portions at each of the stations; the trans-
CHRISTIAN ARCHITECTURE IN THE EAST.

When we speak of Christian Architecture, we are generally understood to mean either some of the Gothic styles, or at the utmost some of the various forms which the Romanesque architecture, during its greatest development, in the ninth century, such as the Lombard, Teutonic, or Norman. But this is at the least a very narrow and limited sense, for it amounts to the ignoring of all that was done by Christians before that period; men shut their eyes to the fact that in the East there were architects and church-builders none the less expert, and more original than those in the West; for they invented a style of greater grandeur in its masses, and more magnificant in its decorations (when properly carried out), than any style that prevailed elsewhere. I mean the Byzantine; and I speak deliberately when I say that the interior of St. Sophia's at Constantinople—the building in which Byzantine architecture first came into perfection from the brain of its inceptor, Anthemius—like Pallas from the head of Jove, garnished at all points, presents the finest interior in the world. In the first place, it has that great element of architectural grandeur, massiveness, in its enormous piers and vast arches, from which spring the pediments of the flat dome, which, by the way, is far more imposing than a lofty one like St. Paul's or St. Peter's, for the dignity of these can only be fully appreciated when you are immediately beneath them, and looking upwards. It possesses appropriate decorated construction in its columns of every kind of rich marble, its carved capitals, rich inlaid spandrels, and in its ornamental decorations, which is never found in the West. Even the softs of the arches, as those of the dome and apse have been whitewashed by the Turks. All this is perceptible at a glance, all taken in in one view, hence the sublimity of a coup d'oeil which surpasses in effect the interior of Milan Cathedral, which is perhaps, independently of detail, the finest interior of the West.

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

The lecturer said that he should be inclined to divide the epoch of Byzantine art into four periods. Assuming the reign of Justinian, from A.D. 527 to 565, to be the purest period, equivalent in its simplicity, magnificence, and power, to the golden age of Greece, we may consider the buildings erected between the time of the foundation of Byzantium and the time of Justinian, as belonging to the first period; those erected by Justinian to be of the second; from the end of his reign to the year 1000, to be the third period; and from the middle of the fall of the fourth to the fourteenth century, to the fall of the empire. In this division to these general divisions, there were those of geographical and local character, such as those of the Armenian, Georgian, and Servian styles. Hence the field offered for archaeological research in the East was as wide as that in the West, and it also had the advantage of being comparatively untrodden ground.

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

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

Amongst the host of remarkable churches, one may be specially mentioned for its size and magnificence. It is in reality four churches combined into one, with aisles on each side, with aisles above, standing at right angles to one another, so as to leave to their intersection an open court, octogonal in plan, in the centre of which is a socket where formerly was the pedestal of the column upon which stood that remarkable pillar-stone, St. Simon Stylites. It is of unknown building, of which this group of buildings was the copy; and of these the church of which St. Simon was the founder is the only one that still has its own roof. Many of these churches have been rebuilt, but their roofs to restore them. These edifices are confined to two districts in Syria, one the Hauran, east of Damascus, and the other that around Aleppo; as both these districts are unvisited by the ordinary traveller, these archeological treasures have remained unknown for centuries.

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

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

The interesting part of this architecture, I now commend to your notice. But some of you may be inclined to say—Of what practical use can a knowledge of it be to us: now-a-days we cannot afford to waste materials in erecting massive piers, or to construct immense domes over our churches, as the former would obstruct both sight and sound, and the latter would require more science in their construction than groining, and without decoration would have a bare and baulk effect. In answer to this, I may urge that, as the architects of the twelfth and thirteenth centuries in Acquaintina adapted the Byzantine dome with great success, altering its proportions and making it pointed instead of flat, in order to suit their modern style—especially that of the south facade of the church of the Holy Sepulchre—Mr. Pullan’s example should not be neglected in our town churches. Those who know Angoulême cathedral will remember what breadth and dignity it gives to the aspect of the interior, and, now that we have a rising school of decorators, the bare effect might be removed by frescoes or distemper paintings.

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

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

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

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

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

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

Mr. Riddett inquired what was the heastfien signification of the dome, to which the President had adverted.
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

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

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

Mr. Bingham called the attention of the meeting to an advertisement issued by the Trustees of St. Mary's, Islington, calling for designs for a workhouse, and offering to pay the architect 24 per cent. upon the outlay. The Trustees also offered premiums of £100, £50, and £25, respectively, to be awarded to three designs which are to become the property of the Trustees. With regard to the third premium, he hardly thought £20 a proper price for a design for a workhouse for a thousand persons. He thought that the question of the two-and-a-half per cent. put forward, in such an unbusiness-like way, ought to be taken notice of by the association in some manner.

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

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

Mr. Ridgeway seconded the resolution, which was carried.

EXPERIMENTS IN MIXING AIR WITH LOW-PRESSURE STEAM.*

By T. McDonough.

The apparatus used is a simple form, steam being generated in a small boiler and allowed to escape through a nozzle so as to strike upon the fans of a little air-mill. The quantity of steam escaping in a given time, and the number of revolutions introduced in the air-mill by this means was determined in the first place by direct experiment. Air from a gas-holder under moderate pressure is then allowed to flow into the rear of the same jet and issue with the steam. The amount of air so added, and the number of revolutions in the air-mill during a given time being again determined, it is thus found that the addition of a small amount of air, say 1/4 of that of the steam, would increase the number of revolutions in the mill by a much greater quantity, as in this case by 14.

The following table exhibits the result of many experiments:

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Example.—In the first column, by adding 43 inches of air to 432 of steam, the wheel increases its speed from 60 to 73, or about one quarter for an added volume of one-tenth. This action it is proposed to apply to steam engines by so arranging the valves, &c., that air in place of steam will be admitted during the first part of the stroke, after which the steam will be admitted and mix with this air.

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

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

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

REFERENCES.


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

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

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

The first volume, as now issued, contains nearly half as many more pages as the first volume of the Handbook, and one-third more woodcuts; but the addition thus made to the bulk and richness of the work is by no means the most important part of the change. The division of mankind into races, and the variations in art, consequent on the natural capacities or qualities inherent in each race, a subject slightly touched upon in the Handbook, is now made to form a great extent the key-note of the treatment of the subject; and this gives a philosophic value to the re-issue greatly in advance of the older work, excellent though that undoubtedly was in many most essential particulars. It is true that on this score the work may be considered now more open to criticism than it was in the

* From the Journal of the Franklin Institute.
original form, but for this Mr. Fergusson is prepared, remarking, with great justice,

"My conviction is, that the lithic mode of investigation is not only capable of supplementing to a very great extent the deficiencies of the graphic method, and of yielding new and useful results, but that the information obtained by its means is much more trustworthy than anything that can be elaborated from the books of that early age. It does not access to sources of information of which they do not suspect the existence. While they were trying to reconcile what the Greek or Roman authors said about nations who never wrote books, and with regard to whom they consequently had little information, I was trying to read the history which these very people had recorded in stone, in characters as clear and far more indelible than those written in ink. If, consequently, we arrived at different conclusions, it may possibly be owing more to the sources from which the information is derived, than to any difference

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

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

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

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

"The first, which may be called 'Ancient or Heathen Art,' to consider all those works which prevailed in the ancient world from the dawn of history to the disruption of the Roman Empire by the removal of the capital from Rome to Constantinople in the fourth century. The second to be called either 'Medieval,' or more properly 'Christian Art.' This again subdivides itself into three easily-understandable divisions: 1. The Romanesque, or Traditional style, which prevailed between the ages of Constantine and Justinian; 2. The Gothic, or Western Christian style; and 3. The Byzantine, or Eastern Christian style. Either of these two last might be taken first without incongruity; but, on the whole it will be convenient, first to follow the thread of the history of Gothic art, and return to take up that of the Byzantine afterwards. The Western styles form a complete and perfect chapter in themselves, based directly on the Romanesque, but borrowing very little and lending less to others during their extension. They also perished earlier, having died out in the sixteenth century, while the Byzantine continued to be practised within the limits of the present century in Russia and other Eastern countries. Another reason for taking the Gothic styles first, is that the extinction of the Byzantine style is directly connected to this arrangement would follow naturally after it. The third great division of the subject I would suggest might conveniently be denominated "Pagan." It would comprise all those minor miscellaneous styles not included in the two previous divisions. Comprising the Sassanian and Saracenic, it would include the Buddhist, Hindoo, and Chinese styles, the Mexican and Peruvian, and lastly, that mysterious group which, for want of a better name it may be convenient to call the "Celtic." By this consecutive arrangement can be considered advantageous. The fourth and last great division is that of the 'Modern or Copying styles of Architecture,' meaning thereby those which are the products of the Renaissance of the classical styles, that marked the epoch of the cinquecento period. These have since that time prevailed generally in Europe to the present day, and are now making the tour of the world. Within the limits of the present century it is true that the copying of the classical styles has to some extent been superseded by a more servile imitation of those of mediæval art. The forms have consequently changed, but the principles remain the same. It would of course be easy to point out minor objections to this or to any scheme, but on the whole it will be found to meet the exigencies of the case as we now know it, as well or perhaps better than any other."

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

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

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

This book is a very superior essay on one of the most important subjects of the day, and enriched with a large amount of valuable information, partly embodied in the text, and partly embodied in notes and an appendix, but remarkable for a clear, comprehensive, and well expressed statement of the case, where it is true, being illustrated through the action used by Mr. Ferguson, of which we have given a notice, which still needs to be urged on public attention in every possible way.

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

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

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

"To sum up briefly the conclusions to which all who are conversant with this subject have arrived, it appears that what is now more particularly wanted to improve the sanitary conditions of the large masses of the population are the following:

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

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

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

* As the Poor-Law Board does with the Board of Guardians.
† No uniform rule, founded upon general principles, exists to determine the amount of open space per house required in different towns, extracted from the Bradford Report on the Building bye-laws. — 11
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

Feb. 1, 1866.

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

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

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

6. Inducements to the working classes to become the owners of their dwellings, by increased facilities in the purchase of land, by removal of legal hindrances by simplifying the process already adopted, and the conferment of the privilege of the borough franchise on every working man who acquires such ownership.

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

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

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

<table>
<thead>
<tr>
<th>Name of Town</th>
<th>Area of Open Space required</th>
<th>Distance across.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradford, Morley</td>
<td>150 square feet</td>
<td>10 feet</td>
</tr>
<tr>
<td></td>
<td>1 Story</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Stories</td>
<td>12 do.</td>
</tr>
<tr>
<td></td>
<td>3 Stories</td>
<td>16 do.</td>
</tr>
<tr>
<td>Bangor, Brighton</td>
<td>150 square feet</td>
<td>10 feet</td>
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<tr>
<td></td>
<td>1 Story</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Stories</td>
<td>15 do.</td>
</tr>
<tr>
<td></td>
<td>3 Stories</td>
<td>20 do.</td>
</tr>
<tr>
<td>Barnsley, Derby</td>
<td>150 square feet</td>
<td>10 feet</td>
</tr>
<tr>
<td></td>
<td>1 Story</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Stories</td>
<td>15 do.</td>
</tr>
<tr>
<td>Doncaster, Derby</td>
<td>150 square feet</td>
<td>10 feet</td>
</tr>
<tr>
<td></td>
<td>1 Story</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Stories</td>
<td>15 do.</td>
</tr>
<tr>
<td></td>
<td>3 Stories</td>
<td>20 do.</td>
</tr>
<tr>
<td>Grimsby, Leicester</td>
<td>150 square feet</td>
<td>10 feet</td>
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<tr>
<td></td>
<td>1 Story</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Stories</td>
<td>16 do.</td>
</tr>
<tr>
<td></td>
<td>3 Stories</td>
<td>20 do.</td>
</tr>
<tr>
<td>Newmouth, Warwick</td>
<td>150 square feet</td>
<td>10 feet</td>
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<tr>
<td></td>
<td>1 Story</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Stories</td>
<td>16 do.</td>
</tr>
<tr>
<td></td>
<td>3 Stories</td>
<td>20 do.</td>
</tr>
<tr>
<td>Bolton</td>
<td>150 square feet</td>
<td>10 feet</td>
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<tr>
<td></td>
<td>1 Story</td>
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</tr>
<tr>
<td></td>
<td>2 Stories</td>
<td>16 do.</td>
</tr>
<tr>
<td></td>
<td>3 Stories</td>
<td>20 do.</td>
</tr>
<tr>
<td>Bradford, near</td>
<td>150 square feet</td>
<td>10 feet</td>
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<tr>
<td>Manchester</td>
<td>1 Story</td>
<td></td>
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<tr>
<td></td>
<td>2 Stories</td>
<td>16 do.</td>
</tr>
<tr>
<td></td>
<td>3 Stories</td>
<td>20 do.</td>
</tr>
<tr>
<td>Bradford, near</td>
<td>150 square feet</td>
<td>10 feet</td>
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<tr>
<td>Manchester</td>
<td>1 Story</td>
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<td></td>
<td>2 Stories</td>
<td>16 do.</td>
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<tr>
<td></td>
<td>3 Stories</td>
<td>20 do.</td>
</tr>
<tr>
<td>Panasonic, Warwick</td>
<td>to five parts built upon</td>
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</tr>
<tr>
<td></td>
<td>of breadth of the building.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40 feet across.</td>
<td></td>
</tr>
<tr>
<td>Coventry</td>
<td>2 Stories and above.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60 feet across.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 or 3 roomed houses.</td>
<td></td>
</tr>
<tr>
<td>Darlington</td>
<td>Larger houses.</td>
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<tr>
<td></td>
<td>One-half of the entire area of the ground.</td>
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<tr>
<td></td>
<td>One-third of the entire area of the ground on which the house shall stand.</td>
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<tr>
<td>Sunderland</td>
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</table>

"The improvement of the dwellings of the poorer classes, to any appreciable extent, is not a work which can be accomplished by charitable subscriptions. Philanthropy can scarcely be expected to grapple with an evil of this magnitude. It may give the impulse, but the work must be conducted by wise organisation and on ordinary commercial principles. In short, unless experiments in this direction pay, they will not be repeated, and they must pay as much as any of the ordinary industrial enterprises for the trouble and risks connected with the undertaking of this description. The attempts hitherto made, though successful in some respects, have not fulfilled this cardinal condition. Most of the model lodging-houses of London have not averaged 4 per cent. The Improved Portsadritional Dwelling Company (London), established in consequence of the success of Mr. Alderman Waterlow in the erection of Langbourne Buildings (paying 8 per cent.), have indeed a prospect of much better dividends. The four blocks of buildings they have built show a probable profit of from 6 to 9 per cent., and the dividend already paid is 5 per cent.

The earlier London societies, while fully alive to the importance of making their undertakings pay, have found the conditions of the problem too strong for them, and hence it is benevolence, not commercial enterprise, that has found the capital. So, too, with single dwellings. However remunerative in other respects, the disagreeable fact remains that the return is only 4 per cent. upon the outlay of Mr. Salt at Saltairs, and Mr. Akroyd at Copley. These experiments, however, are exceptions to the general rule, the profit and the motive being the same.

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

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

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

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

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


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

ARTIZANS' DWELLINGS, WEST HILL PARK, HALIFAX.

We give illustrations in this number of some of the dwellings composing the group of which a block plan, and perspective view were illustrated in our last. By reference to the details there given, it will be seen that, of the two classes of dwellings forming the subject of our present illustrations, those of Class No. 4 have cost about £160 for each house, and Class No. 3 are to cost £270 each, land and all contingent expenses being included in each case. Those familiar with the subject will recognize the cost of Class C probably provides for better finishing than is obtainable in such buildings, and in that case is not excessive. The planning and general treatment of both these designs are good, and reflect credit on the architects, Messrs. Paul and Ayliffe, of Manchester.

INSTITUTE OF BRITISH ARCHITECTS.

At the ordinary general meeting of the Institute of British Architects, held on the 32nd ult., Mr. A. J. B. Beresford Hope, M.P., President, in the chair, after the usual preliminary business of the evening, the President presented to Prof. Thomas L. Donaldson, past president, Emeritus Professor of Architecture at University College, London, a gold medal bearing his portrait, struck at the instance of his professional brethren, to commemorate his earnest and zealous services in promoting the study of architecture.

In an eloquent address, the President referred to the distinguished services which Prof. Donaldson had rendered to the cause of architecture in this country during his lengthened career, and stated that it was mainly through his personal exertions that the Institute first took complete form and action in the year 1832, under the presidency of the late Lord Grey, with Mr. Donaldson as the Secretary, and who at the request of the Council read a very able and comprehensive paper pointing out the various ways in which the members of the profession might make themselves useful to the cause of architecture. Fifteen years subsequently added, Mr. Donaldson was presented by the same nobleman with the Royal Gold medal of the Institute. Coming down to the period when Mr. Donaldson was appointed Professor of Architecture in University College, London, the President spoke of the distinguished manner in which the duties of that important position had been discharged by that gentleman, having during his period of office educated 400 students in architecture; and in conclusion he expressed a hope that, although Prof. Donaldson had at his advanced period of life felt it due to himself to resign that appointment, it was not to be regarded as an intimation on his part of his intention to retire entirely from that sphere of usefulness, study, and research which had characterised him from earliest life until the present day.

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

Mr. John W. Pape, Fellow, then read an interesting paper "On the Roofs of the Hypothalamic Temples of Assam and Equina."
they successively created Mr. Locke a Chevalier and Officer of the Legion of Honour. About the year 1849 he became the representative in Parliament for the borough of Houlton, for which he sat for thirteen years, and enjoyed the full confidence of his constituents. We have not to deal with Joseph Locke as a politician, as a legislator, but chiefly as a railway engineer; and there is no work in which Mr. Locke gradually relaxed his business and Parliamentary avocations, still, however, continuing to be the valued adviser of certain railway companies; whilst at other times he appeared at the annual public meetings as a severe critic of their proceedings when their policy was not identical with his own. In the presence of Mr. Locke, who was not identified himself in several useful charities, and devoted to the Institution of Civil Engineers even more attention than he had previously given, probably with an inward feeling that in the removal of Cutlitt, Rendell, Brunel, and Stephenson, it was lucubrated upon him to watch over that institution which had been their leader and mentor. His instructions to this board is that the chairman should be in the hands of every young engineer. Gradually, however, he withdrew more from public life, and devoted himself to country occupations and field sports, which on the Scottish moors he highly enjoyed. You, men of Barnsley, always occupy an elevated position in the social scale, and I was glad to hear that you gave him a most cordial welcome, listened to his advice and pleasant jokes, expressed to him the wants of your town, and in all ways treated him as a trusted friend and counsellor, and right well he merited your confidence. He went home fully imbued with all your views of what should be done for the benefit of your town, and Mrs. Locke has religiously carried out his views; you know how thoroughly she has acted in accordance with these views in the free gift of this ground, the Locke Park, with an endowment for its maintenance, a most liberal endowment for the grammar school—where he derived the rudiments of his education. — Mr. Locke did not confine his liberality to Catholic schools, and other well-considered and well-bestowed charities. These all attest the kind intentions of Joseph Locke and the noble manner in which that excellent lady, Mrs. Locke, has carried them out. My mission must end with the expression of regret we all feel at the too early removal of the last of the trio of Brunel, Stephenson, and Locke, — what a great loss to this country as a great man, and how much the public has lost in the loss of a man of such public usefulness—and to express my admiration of this fine work of art by Baron Marchetti, which we now entrust with confidence to your safe keeping.

To a resolution thanking the donors for the statue, Mr. John Fowler, President of the Institution of Civil Engineers, said —

"Gentlemen, on behalf of the donors who have presented the statue to the town of Barnsley, permit me to thank the inhabitants for the resolution which has just been read, and at the same time to assure them that, in the opinion of the friends of the late Mr. Locke, the statue has now been placed in its best and most appropriate position. Of so high a character must not a statue fail to exercise a beneficial influence on the future career of many young men of this busy district, besides being in itself an ornament to the town. The admirable address which we have heard from Lord Alfred Paget, has left little to be added by those who follow him. Personally I esteem it a great privilege to be present at the interesting proceedings of this day; and I am sure it must be a subject of peculiar gratification to the friends of the late Mr. Locke, as it is to myself, that one who knew him so well and valued him so highly, and who is himself so much respected by the engineering profession, as Lord Alfred Paget, should have consented to take such an honourable part, as a realisation of this record of our late friend, and also in taking the chief part, this day, in the inauguration of the 'Locke Memorial.' I can assure the inhabitants of Barnsley, and the numerous friends and admires of Mr. Locke now assembled here, that the members of the Institution of Civil Engineers of England, of which I have now the honour to be a member, take a deep interest in these proceedings, and that they sympathise con-
Font in St. Mary's Church, Winkfield, Berks.

Font in St. Mary's Church, Barbados, W.I.
ACCOUNT OF THE RESTORATION OF THE DUTCH CHURCH, AUSTIN FRIARS.*

By Edward Penson.

The church and convent, as rebuilt in 1354, must have been of considerable extent, for the buildings and grounds extended from Broad-street northward to London-wall, and from the north corner of Broad-street to the churches of St. John, St. Thomas, and the cloister, which last appears to have been on the north side of the church; the churchyard was on the east side. At the intersection of the cross there was a spire or steeple, which was regarded as one of the remarkable objects of London; for Stowe, writing in 1693, says, "The church is a large thing, having a most fine spiral steeple, small, high, and straight; I have not seen the like." This small spiral steeple was overthrown by a tempest of wind in the year 1392, but was restored again. It stood nearly up to the sixteenth century, when it became dangerous; for we find the Lord Mayor and citizens, writing to the Marquis of Winchester, to whom the property then belonged, on the 4th August, 1600, requesting him to restore the steeple, as it appears he had promised to do, and threatening legal proceedings if he did not; but promises and threats again bore no fruit, and the head of the church was taken down, and, says Stowe, "houses for one man's commodity raised in the place, whereof London hath lost so goodly an ornament, and times hereafter may more talk of it."

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

The west front of the building, together with part of the north aisle, were the most conspicuous; the other portions being surrounded by buildings. Its large west window, not remarkably good in character, and its decorated aisle windows, formed one of the most noticeable remnants of Medieval architecture which the City contained. The exterior had been carefully repaired about 1825, but owing to the want of knowledge which prevailed on that date, it was in the early part of the century, not in the careful manner which characterized the restoration of the Dutch church, and that was, however, then a matter of comment, and the subject was warmly discussed in the 'Gentleman's Magazine' of that date.

The old water-tables of the buttresses appear to have been removed, and the decaying mullions and tracery—chiefly of Reigate stone—had much repair and much restoration; the roof of the Dutch, and the surface of the walls rendered over with the same material, whereby nearly the whole of the old work was covered up. Over the west door a canopy appears to have been added. Some further restorations were in progress in the year 1832, when a fire destroyed a large portion of the work, and left the building in a condition which appeared ruinous. Nearly the whole of the roofs of the north aisle and nave were destroyed, and the upper parts of the masonry much injured, but fortunately the tie beams of the nave were left remaining, although damaged. After the fire the building was surveyed by the fire office surveyor, who considered it past repair, and such was also the opinion of the district surveyor, who officially examined it. The church was then put into the hands of the East End Benefit Society, and a committee was appointed to do what could be done to save it. At this time I was professionally consulted. I found the building in the state I have partially described. The pillars on the south side of the aisle were not only as much as 17 inches out of the perpendicular, but the whole church had taken a southward settlement. On plan at the level of the top of the walls having shown form, great irregularity is observable, where on the north side of the south aisle the versed line of the arc was, and still is 17. On the north side of the aisle it was somewhat less, and on the inside of the external walls of the north and south aisles it was less still; the external walls of the south aisle had suffered the least movement, especially the wall on the north side.

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

* Paper read at the Royal Institute of British Architects.
being utterly disproportionate to the requirements of its congregation, I came to the conclusion that it would be in all respects more desirable to pull down the existing—as it appeared—ruinous fabric; the restoration of which would necessarily be very costly, and too small a building. No other church more suited to the requirements of the congregation, and more suitable to the task of being a monument of public faith and piety, than the present church. This was accordingly done; when it having become known that it was the intention of the trustees to remove the old building, so strong a manifestation of public feeling was evinced by letter in the daily papers, of July 1863, and very influential and pressing representations made to the minister and elders of the church, that the trustees were led to reconsider the question. Although I still held unaltered my views as to the practical utility of erecting a building more consonant with the requirements of the congregation, I felt there was no absolute impossibility in preserving the work as it stood, and in effecting a restoration. The committee of the Dutch Church, feeling that they were trustees, not only to a limited congregation, but to the general public, who they believed, by the strong expression of opinions which were made, were seriously desirous of retaining the old church, resolved in deference to the opinions so expressed, to abandon their original intention, and, if practicable, to restore the church. I therefore, in conjunction with my late friend Mr. Light, was put in charge of the work of restoration. The altar table was raised on a platform enclosed with a wooden balustrade, with wall linings at the back of a more ornamental character; all of the work of the end of the seventeenth or beginning of the eighteenth century. The altar was decorated by a painting representing an arcade of the Ionic order, containing the Creed and Commandments, and recommended the entire removal of the vestries, organ loft, and libraries. We also recommended the removal of the south wall, which was not without its picturesque aspect, and to replace it by a doorway more in accordance with the style of the church; for this we had no precedent, and it is strictly an addition. We also recommended the enclosing by wooden screens of the bays at the east end of the church, which afforded ample space for the congregation; and we recommended the decoration of the broad wall space at the east end by a fresco painting, but this being inconsistent with the service of the church was not carried out, nor were we allowed (as was also suggested) to use any coloured glass for the windows. After the resolution which the trustees came to at the end of July 1863, to restore the church, and certain arrangements necessary in consequence of the altered plans, some time necessarily elapsed before contracts could be obtained for the restoration, and it was therefore not until October of that year that the tenders were received and the work was actually commenced.

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

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

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

The internal masonry was now cleaned, and the chalk facing re-pointed. The tracery of the windows, which it was intended to retain, on examination proved to be impracticable, for most of the stone was in the windows, and could not be taken into the holes of the mullions, which round twine had been twisted, and the mouldings run in cement. The tracery also was so much defaced, and so injured by decay, that it was found necessary to restore the whole, which has accordingly been done, and a careful and faithful restoration made in Portland stone. The old tracery was of several kinds of stone, principally Anhoby and fire stone. The graves with which the area of the church was covered, and of which many had been burst in by the falling of the roof timbers at the fire, were filled with concrete, and the stone paving re-laid, care being taken to retain every old stone, including those in which brasses had been inserted, of which there is a goodly number, principally of Purbeck marble, and every brass had disappeared. The eastern part of the church is now enclosed by an oak screen, and the pulpit, organ case, and seats required for the congregation, are constructed with oak.

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

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

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

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

THE NEW ATLANTIC TELEGRAPH SCHEME.

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

The opening said it would be useless for him to explain the causes that led to the failure of the two attempts to establish this telegraphic communication by the Atlantic Company. They were too recent and too well known to those interested on the subject; the Atlantic Company, nothing daunted by their failures, were again in the field, and not only for the purpose of laying another line, but with a determination that hopes are not always disappointed, and that even after the one they had lately lost, repairing it, and completing a second line to Newfoundland. Another company was, he was informed, in the course of formation for carrying out what was called the Northern route, and for which they had obtained the concession from the Danish Government, first granted to Colonel Schaffner.

He believed it was their intention to lay a cable to Norway, and from thence to Labrador, e/w Iceland and Greenland, a route that certainly had the advantage of short sections. It would be seen from the advertisement calling this meeting that another candidate was in the field, with another route and a new cable—not the same cable, for part of it, some sort of it, however, but owing to the inventor (Mr. Macintosh) having been connected with the Gtta Percha Company, his patents have been in a manner tied up. He thought the best course to adopt on this occasion would be to give Mr. Macintosh the opportunity of explaining the nature of his cable, and of the advantages which it offered for laying and utilizing it, both in a military and commercially; and then, taking those advantages in the same order, he should be glad to hear the remarks of any electrical present on the electrical properties; and on that important part of the subject he had no doubt the meeting would prefer to hear the result of practical tests rather than theoretical hypotheses.

He thought that the time was not far off when the remarks of any telegraphic engineer or cable manufacturer on the other points; and if any practical gentleman desired to make any remarks on the cables or routes, he had no doubt the meeting would be glad to hear them, and, finally, he hoped that the discussion would be conducted with such precision as was so necessary to enable them to derive absolute benefit from it.

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

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>New Atlantic</th>
<th>Macintosh's</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity in lbs. copper</td>
<td>300 lb.</td>
<td>300 lb.</td>
</tr>
<tr>
<td>Weight of insulating material</td>
<td>400 lb.</td>
<td>400 lb.</td>
</tr>
<tr>
<td>Inductive resistance in lms.</td>
<td>400 lb.</td>
<td>2000 lb.</td>
</tr>
<tr>
<td>Diameter of cable</td>
<td>1 1/4 inch</td>
<td>4 1/8 inch</td>
</tr>
<tr>
<td>Weight per nautical mile in air</td>
<td>35 ft.</td>
<td>6 ft.</td>
</tr>
<tr>
<td>Weight per nautical mile in water</td>
<td>7 1/4 cwt.</td>
<td>1 1/4 cwt.</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>5.1</td>
<td>1.5</td>
</tr>
<tr>
<td>Breaking weight</td>
<td>11,000 fath.</td>
<td>17,000 fath.</td>
</tr>
<tr>
<td>Weight of 2800 nautical miles of cable</td>
<td>4,111 tons.</td>
<td>718 tons.</td>
</tr>
</tbody>
</table>
From the above statement it will be seen that 2000 lb. of gutta-percha are only equal, for purposes of insulation, to 400 lb. of Macintosh's compound, and the respective cost of the materials per pound is at least three to one in favor of the compound.

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

Captain Selwyn said it was necessary to know that sort of cable could be expected for £100 per mile, and what size leads behind, and what is the rate of speed? Would the cable be of the same length and with the same speed, or of greater length with the same speed?

Mr. Macintosh said the cost of the line to Newfoundland would be £100,000, and with the same sized conductor he could get at least 100 miles. He did not understand the method of converting them, forming signals. The Government had a patent. The Government had a patent. The Government had a patent.

Captain Selwyn regarded with interest the development of a new material of so much promise. He believed that the statements of the inventor as to the advantage of the material could be proved, and he considered it as applicable to underground electric telegraph lines as submarine cables. The route proposed by Mr. Macintosh was one in which there was no deep water for any great length. The distance to the first sandbank was 900 miles, the next distance was 500, then came another 500, and then one of 430. In no case was the depth more than from 100 to 200 fathoms, so that the cable might be easily recovered if broken, and the risk to the shareholders was consequently diminished. The laying of the cable is a matter of little advantage or disadvantage, but when the cable is laid in deep water it is a matter of price. The ships are apt to be more expensive.

Captain Selwyn said he had no intention of laying cable for the Atlantic Telegraph Company's cables. He remarked that, as there was nothing to pay for concession, the advisability of forming a company to carry out the scheme was well worth of consideration.

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

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

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

THE MONKS' CHAPEL, NORWICH.

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

It stands 16 feet parallel to the longest side of the premises, and 10 feet from the north end; thus there is room for an aisle some day, when the intrados of the nave arcades will be cleared away, opening four bays of 14 feet by 20, the two Doric columns standing, the two spandrels will then be carried over the aisle, and cut away from their present position. The ground on the other side is irregular, but the adjoining property is very narrow, so perhaps the aisle will be completed on the other side as well, some day: then the chancel will be extended, the windows filled, and the spandrels will then be carried over the aisle, and cut away from their present position. The ground on the other side is irregular, but the adjoining property is very narrow, so perhaps the aisle will be completed on the other side as well, some day: then the chancel will be extended, the windows filled, and the spandrels will then be carried over the aisle, and cut away from their present position.

In the centre of the floor of the entrance-hall is a diamond stone, bearing in illuminated characters the names of the various donors whose gifts embellish the hall. There are various emblematic designs about the building. The lodge-room is 45 feet long, 32 feet wide, and 17 feet high. At the eastern end is an above, and at the western end is an arch, the lower part of the arch being an enriched arch, with pomegranates, lilies, and emblems pertaining to the various degrees in masonry, keyed in with a Masonic stone, in which is sculptured the All-seeing Eye, the radiations of which will, when finished, be enriched with gold. The canopy of the arch is surmounted with stars, which will be gilt, on a ground of cerulean blue. The whole length of the arch of the span of the arch will also be in gold. A dais will be erected, on which will sit, beneath the canopy, the W.M. of the lodge and brethren who have qualified themselves to occupy that position. The means of lighting the room by day is by two large margin ceiling-lights, with Masonic medallions, and plain and coloured glass. At the western end and the organ gallery. The organ in the room harmonises with its character. Masonic colours—crimson, purple, and sky-blue—have been used throughout. The builder was Mr. J. A. Pettitt. The stonework was done by Brother Chinnoch (Towell, Chinnoch, and Co.); the gas, &c., by Brother Lucas. Brother C. T. Townsend designed many of the decorations.
THE ARCHITECTURAL ASSOCIATION.

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

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

ON THE PROSPECT OF IMPROVED DWELLINGS IN LONDON.

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

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

In the suburbs houses are springing up in all directions, yet how few, if any, have been designed by an architect, and are being erected under his superintendence. Does this not suggest a want of public confidence in the profession? But, says the Architectural Student, I have turned my attention to domestic architecture; there is not sufficient scope for the practice of the art: I wish to design a building which shall be at once an illustration of my professional skill. I would answer to this, that the young architect may find some difficulty in obtaining the area for the exercise of his skill which he thinks he ought to have; whereas the old evil of building, although often prospers, is no proof of the skill of the architect; it only shows him he is competent to do so. To return to the subject before us: what are the defects, and the prospect of improvement?

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

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

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

It has often been urged on behalf of scamping builders, that the public who buy are alone to blame—if there were no buyers of cheap houses there would be no builders. That is true to a certain extent, but how many of the purchasers are in ignorance of the construction of the building? It is prevalent upon the part of the purchaser, that they have been done in a substantial manner. Another, and a very large class of buyers, are those who will buy anything which shows a good per-cent for the capital invested; with those there is only one remedy, and that is very stringent building regulations.

The general public have very erroneous ideas of the Building Act, they imagine that the district surveyor is responsible for all the structural defects in a modern building, and therefore, in many cases are more content with the result obtained than to insist on the perfect condition of buildings, and are satisfied with a very cheap building, not knowing the evils of cheap building. The quality of a house they wish to purchase, they conclude that they are right about the walls and timbers, as the district surveyor has looked after all that.

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

The foundation is the portion of a building which should receive the greatest and that of care and attention, yet how often do we see it otherwise. The Building Act stipulates that the foundation shall rest upon the solid ground, or upon concrete, or upon other solid superstructure. In practice it does not bind the builder to use concrete if the ground is solid, so that we have houses built upon clay, loam, and other soils, without any provision against damp-proof course, or slates in cement; if the result is, the damp rises up the walls like the sap up a tree. I was employed about nine years since, to make an estimate for finishing some cellars at Notting-hill; when I found the damp had risen half-way up the lower story, the necessary precautions not having been taken in the construction, the result is, the house is damp, and the water filled the space under the lowermost floor for ventilation. I have known instances where the cellars have been laid on the ground, and the footings cut away to receive the ends. Yet when this floor was laid everything appeared satisfactory, and if a surveyor examining the premises neglected to have a board taken up he might be satisfied the provisions of the Act had been carried into effect. Houses should be erected with less than one foot clear space under the ground joiats, there should also be a connection with the external air back and front, so that there may be a direct current through. Care should be taken that the ground does not rest against the walls above the level of the damp-proof course; provisions should be made for either an open area or dry area with good ventilation.

Another defect of modern building by which the lives of the occupiers may be endangered is insufficient timbering. Modern builders have found out that the element of strength in a beam is but little derived from the heart of timber, but the strength of the beam is derived from the joints, and not from the timber itself. That this is true is clearly shown, if we consider the weights of such a system may be easily imagined, in some cases they have more than sufficient and in others the deflection is considerable. All portions of timbering there are none so often scamped as the lintels, and when we consider the small proportion they bear to the total quantity of timber in a building, it is surprising that men will injure the stability of a structure by crippling their scalking. Gutter plates in roofs also afford a grand opportunity to the cheap constructor to save timber; it is unnecessary to state that he does not hesitate to avail himself of it, consequently in a short time there is a permanent set; this is one of the causes of leaky roofs.

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

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

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

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

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

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

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

In the interests of health, that they are objectionable in any case; but, if unavoidable, they should be at least half their height above the level of the street, and should not be less than 7 ft. 6 in. high in the clear. Amongst the disadvantages of basements, I may mention that they entail increased cost of drainage of towns. For example, in Southampton, there is an annual expense for pumping, solely on account of a few basements, which induced the surveyor to place his sewers at a lower level than he otherwise would have done. Why architects and builders should have such a great desire to go down below the level of the street with their rooms, and build so high above the earth like their buildings, I cannot conceive. There is plenty of room upwards. Streets in time are raised above their old level; therefore to obtain that amount of light and air so necessary to health, by all means keep your buildings well up. It is argued that you cannot obtain the necessary offices without basements, but in answer to that objection you go down by a stair to an upper floor, and its no mean foundation, it is economical to utilise the space; but why not utilise the space in the roof? In the medieval buildings of some parts of France and Germany, the attics were used for the provision of grain and other stores, where they were kept dry (the roofs being strongly built did not let the rain through); we, on the contrary, place our stores in the cellars, where they, in many cases, become damp and musty.

It is extremely desirable that every living room should be provided with a good larider connected than can be done by means of an opening fitted with perforated zinc; also sufficient space for one ton of coal, not under-neth the larider as in Peabody-square, which I think objectionable; a good sink and sufficient water-supply are also important, if of rain water, as well as spring or river water, so much the better. It is to be regretted that the provisions for the drainage of the buildings is so much of attention which it merits; it is very useful for washing purposes, and, according to Mr. Rawlinson and others, would effect a large saving in soap.

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

The planning of bedrooms also requires more consideration than is usually bestowed on the subject, the position of the bed should be determinate, and not left to the use; I think the French plan of placing it in a recess has some advantages, because it enables a person in indigent circumstances to make one room serve the purpose of two, as the bed can be screened from view by folding doors or by curtains, and at night the occupants have the benefit of a much larger cubical space than can be obtained in the ordinary-sized bed chamber. With regard to the cubical space necessary for a bedroom occupied by two persons, I am of opinion that it should not be less than 1000 feet, although the rooms in the model dwellings designed by Mr. Darbishire contain less than 500 feet each, and the rate of mortality is very low. I now come to a question that is held somewhat strong opinions, viz., ventilation. I consider that it is of as much importance that some means of exit should be provided for the vitiated air, as that a fireplace should be provided with a flue. Every architect should make himself acquainted with the principles of ventilation, and not put himself in the hands of the most ignorant, some he has more knowledge on the subject, and endeavour to give a scientific colouring to their inventions by elaborate diagrams, and all kinds of complicated contrivances.

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

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

I believe that those gentlemen who have erected model dwell-
ings on expensive freehold sites has deterred capitalists from taking up the subject. Many of the buildings so erected pay so small a per-centange, that persons who have embarked in the scheme have done so from pure benevolence. To the credit of the poorer classes in this country, there is an independence of character and of principle, that is not derivable from any pecuniary compensation, which will enable a family to maintain itself in charity, alone sufficient to prevent many from occupying them.

The capitalist should adopt the same means which he would if he were to build any other structure purely for investment; that is to say, select a piece of uncovered ground at a reasonable ground rent, with long leases, and erect his dwellings thereon by contract.

With regard to design in art, in my view there is much to be done. I fear the public are not sufficiently educated to appreciate art-work; they know that a picture or a statue is a work of art, but they do not know that a building may be, or ought to be, equally so: they weigh only their market price, that is to say, the cost of the material and labour, and the profit thereon; they do not appear to understand that a building produced by an architect, who is an artist in every sense of the word, is as priceless as the works of a painter or sculptor, and should be paid in proportion to its artistic value as a work of art. In treating my subject I have not placed architecture as an art last on my list, because I think it of secondary importance, but I have merely followed the ordinary professional custom, viz., the plan first, and the elevation afterwards. If we criticise the ordinary outline of our dwellings in the Metropolis, we shall find them to resemble so many square blocks, with openings therein for doors and windows: there is a total absence of shadow and relief. The architect is the first man who can give so much to secure the confidence of a client as a correct estimate; many persons have told me they prefer to buy a house, to have one designed and built under an architect, because it is sure to cost more money than they anticipated or were informed by their architect.

Next in value to the employment of an architect, as a general rule, is the design of the site. I think the architect should be the only person who can make so much of that part of the building which is so much to secure the confidence of a client as a correct estimate; many persons have told me they prefer to buy a house, to have one designed and built under an architect, because it is sure to cost more money than they anticipated or were informed by their architect.

The Local Government Act is in some respects a much better measure, as it gives powers to local boards to make bye-laws as to the height and shape of buildings, but it is far from adequate, and in a few cases the building act is only a sort of a ground story, a front elevation and transverse section of the proposed building, for the approval of the district surveyor; it would then be the duty of the district surveyor to examine such plans, and, if satisfactory, give notice to the builder to proceed. By this means, we should secure one important point, viz., that all persons before building would be obliged to prepare the necessary plans, and not build by rule of thumb, as in many cases they do now. They would have a certain extent be obliged to engage professional assistance, which is a step in the right direction, and would certainly lead the way to better things. By an extension of the present system, the district surveyor would be in a position to remedy the defects of modern buildings pointed out in this paper.

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

* See this Journal, pages 8 and 43 ante.
supervision. Certain fees must necessarily be charged the builder, but they could be paid to the Metropolitan Board of Works when the plans are approved of. The district surveyor should also have an efficient staff of assistants under his control, so that a proper and regular supervision of buildings could be maintained, whereas at present the supervision is most imperfect. I do not cast any blame on those gentlemen who hold the position of district surveyors, the majority of whom are an ornament to their profession, but they are the exponents of a bad system. Neither do I wish to propound schemes which would impose duties upon those gentlemen, which I am not prepared to carry out myself.

Before concluding, I must urge upon the younger members of the profession the desirability of so extending their professional industr and so increasing the value of their services at their proper value. I am not one of those who would stay the making of new streets, new railways, and other improvements, because they take down old dilapidated hovels which are occupied by the working classes. I hope that the work of improvement will go on; that new lines of action will be opened up through the courts and alleys which now disgrace this Metropolis. It is one of the principles invariably followed by railway companies and by other public bodies, in forming new streets, to pass through small property, from motives of economy,—it is well it should be so. Without these improvements, and the consequent demolition of small houses, the question of improved dwellings in London would be as hopeless as the question of improved dwellings in the poorer classes is at present put to much inconvenience from the loss of their homes, to which they had become associated, and were of course very lost to leave. Routes have increased, as they always will do, in proportion as the demand is greater than the supply. But an inquest has been given to the movement; a desire has been evinced by many that the position of the working classes in London should be improved; and if the capital only see, which I feel he must do, that the erection of improved dwellings is a good and a safe investment, we may look to the future with fair hope of success. By improving the houses of the working class we shall remove the social hindrances, you impose a higher thought of emulation and industry, and excite him to feel that he may improve himself, and thereby improve his position. There is no doubt that this is a indirect means by which the mechanical skill of the workman may be increased, that with a better social standing we may ultimately obtain that which is so necessary to the Metropolis, a race of art workmen, having a love for the calling they pursue.

What the condition of the Metropolis is to be in another decade will depend on the architectural ability, business tact, and perseverance of the architectural profession. I trust the younger members, to whom we look for the future status of an architect, will study architecture as a science, not as a speculative business. If they do so, assisted by more stringent building regulations, I think we may say we shall have a very fair prospect of improved dwellings in London.

Mr. Blashill observed, that the present unsatisfactory state of London dwellings was mainly owing to speculative building, a system which, however bad it might be, was in some ways found convenient. He thought the sooner workmen’s dwellings were removed from the Metropolis the better. In the immediate neighbourhood of valuable warehouses and public buildings there were sometimes vacant houses in a wretched state of repair, each inhabited by a number of different families. In the course of events these houses got worse and worse, till they were pulled down, and other buildings more suited to the locality erected on their sites. But this is not the whole of the evil. I have heard of districts of London, where the buildings are so crowded that it is impossible to secure the return of one-half per cent. He however thought it possible that there might be information not given in the report which would modify this conclusion. He considered that the provision for dwellings for working people must be included in the present, when the hope of sufficient profit existed. Property let to working men furnished as good security as that occupied by any other class of the community, as he had lately seen in examining the accounts of building workmen’s houses, which had a rent roll of several thousand pounds per annum. The loss through bad tenants was not 10 per cent. All houses in London were built with the intention of being occupied by one family only, whereas, they were frequently occupied by several different families. It seemed desirable to acknowledge this fact, and build accord-ingly, as people would enjoy more real privacy by living in separate flats in the same system. The law, in its present state, always tended to live and sleep in the centre of London, and good blocks of dwellings for all classes were therefore required. Mr. Blashill observed that inaccessible closets and spaces should be avoided in house-planning, as they tend to harbour dirt and disease. He moved a vote of thanks to Mr. Lemon.

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

Mr. Gilbert Rooke referred to the valuable labours of the Society of Arts, with regard to workmen’s houses. A committee of that body had arrived at the conclusion that it was not likely to be profitable to build them in London, but it was hoped that some of the smaller towns might succeed. From a number of reports he had examined some years ago, he had found that 4 per cent. was the highest rate of interest received on new buildings of this class, while the average was barely 24 per cent. In the barrack system, he believed, what people most objected to was having the staircase in common, perhaps the difficulty would be obviated by having external staircases and galleries.

Mr. J. H. Christian said that the barrack system seemed to be repugnant to the English feeling of independence; perhaps the barrack-like appearance might be modified if the galleries were made broad enough to give the idea of a street; this would make it practicable to introduce small shops. He had, however, little faith in the system, and rather favoured the plan of workmen going out of town, to which he did not object. He considered the reason why one reasonable objection could not be made to return was that houses let by single rooms to poor tenants are very paying property. He could not understand that if new houses were erected on the sites of old ones, such as those between Oxford-street and Chelsea-cross, 3 to 4 per cent. could not be realised. This per-cent would not attract speculative builders, but it might satisfy a large class of philanthropists. He believed cottages would yield a better return than the large barracks system which required the capital outlay.

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

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

Mr. Hindley called Mr. Mathews’ attention to the fact, that all leaseholds and landlards stipulated that the houses should be built substantially.

The President considered it would be a great hardship to the workmen to be obliged to come 8 or 10 miles daily to their work. In all new towns, it was most desirable to secure the working people’s own co-operation as much as possible. In visiting builders’ yards he had been struck by the vast extent of ground covered with low one or two storied shops or stabling, and it had occurred to him that these spaces built (badly enough doubt) for £300 to £500. Furthermore, the erection of buildings containing workshops on the ground-floor, the upper portions being devoted to dwellings for the workmen. The President put the vote of thanks, which was carried.

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

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

AMONGST the wonderful adaptations of physical science to the daily uses of life, there is hardly one which is calculated to excite greater attention than the application of carburetted hydrogen gas to the purposes of illumination. It is essentially a discovery of modern times; for there must be many here present who can recollect the “darkness visible” that enveloped London streets even in the days of Pepys. How soon we have become accustomed to the enjoyment of luxuries, that very often the first steps that attend their acquisition are forgotten, and we take them as matters of course. Somewhat of this kind of reasoning has been adopted with respect to the use of gas; and the public are inclined to expect that the manufacturers of this article, which has now become almost a necessity of life, should give them the benefit of their experience, without taking into account the cost they must have incurred in acquiring it.

The discussions that took place on the occasion of granting the new concession for lighting the city of Paris, and the movement that is at present going on in our own Metropolis, seem to have been marked with this spirit; and though the Paris Gas Company has succeeded in obtaining what may be considered as favourable terms in return for the supply of gas, yet the inhabitants of London evidently are disposed to expect that the companies should supply them at such prices as would hardly leave them a fair profit. It therefore struck me that a statement of the condition under which the Gas Company of Paris has agreed to supply the town with that article of consumption might be of interest, if only to enable the engineer to compare the systems adopted in the two countries with respect to public works; the more especially as it would appear that considerable misunderstanding exists with respect to the rights and privileges of our own consumers, in particular where the supply is to be given by an act of Parliament.

It is proposed in the course of this paper, to notice the points wherein the manufacture and distribution of gas in Paris differ from those which are followed in London.

The formation of the one gigantic monopoly that has the privilege of lighting Paris took place in this manner. There had been several companies that were formed for the supply of the city, which, had, from the period of their first establishment, enjoyed a species of dissecting arrangement, as we should call it, and they agreed to merge their separate capitals in the six companies that had treated with the municipality in the month of December 1846. In the year 1852, when the empire was first established, the government thought it to be in their interest to encourage the formation of great companies who should possess the means of employing large numbers of workmen, and give rise to the profitable investment of capital. The hygienic effect of the establishments for the manufacture of gas in the interior of the town, with the government; and common desires that at least three of four of these should be removed from their original positions in the centre of the town. Under these circumstances it was suggested to the shareholders of the six companies that their union would be received with pleasure; and then that their application for the prolongation of their concession, which expired at the close of 1855, might be entertained, upon conditions that were to be the subject of future deliberation. The consequence of this proceeding on the part of the government may be described, in substance, to have been that the concession for lighting Paris was granted to the united companies on these terms. The three establishments in the interior of the town, that of the Rue de la Poissonière, and the Rue de la Tour de l’Empeur, were to be suppressed, and their manufacture was in future to be conducted in the new gas station that was to be erected at La Villette. The canalization of the interior of Paris (understanding by that term the lines of mains and distributing pipes) were to be altered, and an act of Parliament was to provide for the future upon them; the company agreed to pay the town the sum of £8,000 for the privilege of laying their pipes in the public ways; also it agreed to pay the town two centimes a cubic foot, or about 8d. per 1,000 cubic feet, as a compensation for the octroi dues; moreover agreed to share the profits of the working among the municipality of the city of Paris after the expiration of the first sixteen years.

The material and plant that were employed, and all the land and buildings devoted to the manufacture, were to remain the property of the company for the expiration of the lease, which was fixed at fifty years from the 1st of January, 1856. And the company bound itself, in the meantime, to alter the position of their mains, &c., whenever the town might require to execute works for the water supply, sewerage, &c.; so far, indeed, has the lease foreseen the probability of future operations of this nature, that it provides for the company’s removing their pipes, into any subways that the town might order, we will thereby giving rise to any claim for compensation. For these terms the company agrees to supply gas for the public lighting at the following prices:—There are three sets of flames, that are respectively 2' 9" inches wide by 1' 4" inch high, which is paid per hour, 5s. 3d. per hour, 5s. 3d. per hour, 0' 921f; and 3' 3" inches wide by 1' 11½" inch high, which is paid per hour, 0' 30f. When the gas is sold to the town by metre, it is paid for at the rate of 0' 15f. the metre cube, or about 3s. 4d. per 1,000 cubic feet; the company is obliged to fix, paint, and repair the lamp posts and candelabras, but the town furnishes them. For private consumption, the company was entitled to charge for the gas supplied at the rate of 0' 30f. per metre cube, or about 6s. 8d. per 1,000 cubic feet, upon agreement of three months’ date, terminable at the option of either party; but the parties so receiving the gas cannot employ it without the production of the certificate of the person employed by the town to examine, and who examines the right of fitting and other apparatus. The company is at liberty to modify the terms of payment, in this sense, that it is allowed to receive the payment in monthly sums, but this must be on the condition of its being paid in advance. No subscription whatever can be refused by the company, provided the demand be drawn up in accordance with the manner of the company’s monopoly.

The company is at liberty also to charge at so much per hour, or by the metre. A model of each set or series of meters is deposited at the town hall, and every meter must correspond with the details of these; they are bound to be verified as often as the administration may require. All expenses attending these meters are at the cost of the consumer, whether they are placed in the private house or in the subsequent maintenance of them; practically, they all come from the stores of the gas company. It is to be observed that the gas company is not bound to deliver gas to the private consumer at other periods than those in which the mains would be under charge for town lighting. It was moreover stipulated that if during the period of fifty years, for which this lease was granted, there should be discovered any new system of lighting, the gas company should be bound to introduce it, under conditions that were to be fixed by the municipality; or the municipality reserved to itself the right of granting a fresh concession for the new system of lighting, without being bound to compensate the company.

The lease contains various provisions as to the amount of coal, &c., that the company is obliged to hold in stock, and to the payment of the main, valves, cocks, syphons, &c., that are placed in the public ways; these are estimated, in block, to be worth the sum of two millions of francs, or £50,000, which sum would have to be paid to the company, in case of the town taking the concession into their own hands, or at the expiration of the concession.

The quality of the gas is provided to be such, that a lamp of the first series mentioned, which would consume 100 litres per hour, should give a light equal to 0' 77 of a carrel lamp burning 42 grams of rape oil in the hour; for the lights of the second category, burning 140 litres an hour, the light is to be equal to 1' 10½ of that above given; and for the lights consuming 200 litres in the hour, it is provided that they shall lead yield 1' 7½ of the light of a carrel lamp described. It may be stated that this standard corresponds very nearly with the English one, of what we should call seven and a half.

To enable anyone to appreciate the position that the company occupies under this contract, it is necessary to observe that the coal used in Paris is mostly of Belgian and north of France origin; a small portion of cannel, or boghead, is only introduced when the illuminating power of the gas is below the standard. The quality of the coal is known to the town, according to the figures that were published by the company in the course of the discussion that took place before the treaty was signed, gas, 22' 91 metres; large coke, 31' 11 kilogrammes; breeze, 12' 07 kilogrammes; tar, 4' 56 kilogrammes; and ammoniacal liquor of the value of 0' 036 francs. The quantity of ammonia compounds that are present in the coal is considerable, and the company is
obliged to exercise great precaution in ensuring the propriety of the gas, in order to comply with the clause in their treaty which provides that the means they adopt for that purpose should be the best that are known. Yet with all these drawbacks upon the commercial results of the operation, the Paris Gas Company, in the year of its 10th. anniversary, derived a profit of 19 per cent. on the average rate; whereas the amount of profit is at the rate of 19 per cent.; whilst the average rate appears to have been of about 16 per cent.; a result that would cause great heart-burnings with the municipal reformers and the political economists of our own country, which will not allow any company to divide more than 10 per cent. The dividend for the next year is of 14 per cent. of share capital, 4,000,000 francs, and of bonds of the company about £4,200,000 sterling; or, in all, about £4,000,000, for a total population of 1,600,000 persons, which would make the service at which the gas price of Paris is performed about £2 10s. per head of the inhabitants. This calculation, however, is somewhat in excess of the facts of the case, as the gas company has lately undertaken to supply some of the external villages of the Department of the Seine, such as Romainville, Puteaux, Charvile, St. Denis, Maisons Alfort, &c., which form the subject of a separate treaty; but the above calculation may be taken as representing the proportionate price that is incurred in this service. It may be added that the price that is agreed to be paid by the communes beyond Paris for the lighting, is for the public lamps, 20 centimes per metre cube, or about 4s. 3d. per 1000 feet cube; for the private lighting, 40 centimes per metre cube, or 5s. 7d. per 1000; upon a descending scale that may reach finally, 6s. 8d. per 1000, which is the same rate as in the country houses of the commune; as is 3d. per 1000 for the delivery to the subscriber and is agreed to be paid for this service may be explained by the length of time that is unproductive to the company in these cases; but it certainly seems to be exorbitant, when the freedom of the gas from otrio dues and other municipal taxes is taken into account. The company is bound to conduct, in every instance, the gas from the front entrance of the substance, the latter is entitled to employ whomsoever he thinks fit to execute the distribution of the gas in his interior; and, provided, the subscriber presents the certificate of the prefect or his delegate, that the works are well and properly executed, the gas company is bound to supply the subscribers with gas. The expense of branching upon the main and leading to the meter is, of course, borne by the subscriber; the meters, as was said before, are bound to be of approved patterns, and verified as often as may be required by the police; they are furnished by the company, but are at the charge of the housekeeper, as far as regards their first cost and repairs, if those are taken at his request. The duty of the company is that of supplying the public the supply of the gas consumed in Paris as a municipal service, has entailed upon the private consumers the necessity of paying a higher price for the gas they consume than they would naturally do if the service were left to be regulated by the ordinary rules of trade. To the municipality, in the exercise of its rights over the surface of the road, it is true, and even to the property holders, it is only given power to grant the monopoly of the gas supply to the company, on the condition of the company supplying the public lamps at reduced rates, and of sharing in the profits of the concern after it has been established such a time as is sufficient to relieve it from any chance of failure. It is true that in this manner the towns authorities will be enabled to devote a portion of the profits arising from the sale of gas to the relief of the other taxation of the town; but this is only an indirect way of making the consumers pay for the water, paving, or other municipal services; and it is objectionable, as the control of those services can never be efficiently performed so long as upon the expenditure of the public as the property of the city, is left under discussion. The worst of this system, is, that the price of gas can hardly ever be reduced, as the municipality is directly interested in the maintenance of the rate of profit. The precautions then taken to ensure the delivery and the quality of the gas are, therefore, quite illusory, and they seem to be intended rather to inure to the benefit of the company than to be of real influence upon the operations of the company, for so long as the quality of the gas is equal to the average quality that is distributed in the French towns, there is no probability that much fault will be found with it, let it be ever so bad. At present there may be found a great amount of the ammonia compon dent, it is true; but its illuminating power when compared with the London gas, but this may be owing to the quality of the coal that is used. The effect of the participation of the town in the profits of the company must, however, be such as to superinduce a carelessness on the part of the employees who are charged with the verification of the quality of the gas, and of the means adapted for ascertaining the quantities supplied. There is now apparently a great deal of anxiety displayed by the town authorities about the illuminating power of the gas, and the maintenance of the system of control and superintendence of both the public and private lighting, that appears at first sight to be most efficient. There are twenty-one persons who are constantly employed in testing the gas, and who are paid at salaries varying from £300 a year to £45, the total sum voted for the salaries of these people being, at the next rate of £130; these are 150 inspectors of the public lighting, at salaries varying from £100 a year to £45, who figure in the town budget for a total sum of £10,480; and 33 inspectors of private lighting, who are charged with the verification of the meter; these are paid salaries varying from £940 to £40 a year, and they figure in the budget for £2900. The superintendence of this service is, theoretically, very well arranged; it remains to be seen whether it will really operate for the protection of the inhabitants when the town has a direct interest in the successful results of the company, which it will have when the period of sixteen years, during which the company has the enjoyment of all it can make, shall have expired. All these questions, of the power of a municipality to interfere with a private company, however, form part of the greater question of the organisation of the relations between the public body and the private citizens, that admits a question of widely-different solution, but it would be somewhat out of place to treat of it in a book which has been written without any separate paper. The object of the present one is to endeavour to trace the system adopted by our French neighbours in the supply of gas to their capital; and therefore, after having stated the conditions that the company and the municipality have agreed upon, it is proposed to state the manner in which the former of these parties has endeavoured to fulfil its part of the contract.

There are in the neighbourhood of Paris, and within the lines of the fortifications, ten gas stations, of different capacities, but all subordinate to the great station at La Villette. These stations are—1. La Villette; 2. Les Ternes; 3. Passey; 4. Vaugirard; 5. Ivry; 6. Charonne; 7. Belleville; and the three that are situated in the surrounding communes of St. Denis, Boulogne, and Charenton. As was said, the station of La Villette is the most important of these; it suffices for the manufacture of one-third of the gas that is consumed in Paris; the stations of Passey and Vaugirard supply together almost another third, and the other stations contribute from a quarter to half of the remainder. The centre of the consumption is about the Church of St. Eustache, and the positions of the stations have been so chosen that they are mostly situated upon a circle, whose radius would be about that of the distance of the station of La Villette from that point. The station of La Villette is situated on the town road, and is only separated from the fortifications by the military road; but the other works are often situated in the densely-peopled parts of Paris, to the great dissatisfaction of the Conseil de Salubrite, who complain very much of the smells given off in the process of manufacture. As, however, in all the operations connected with the conversion of the residual products of gas-making are carried on at La Villette, there seems to be little reason for finding fault with the company on this score; but the tendency of the sanitary reformers to hunt up, as if they were, the factories that have been moved once in accordance with their suggestions, is not the less worthy of remark. The preference of the Villers station is evident, in that it is in the north-eastern side of that line; and the establishment for the conversion of the waste products is situated towards the north-west of the retort house, being separated from the latter by the Chemin
d'Aubervilliers. The total area of the establishment is from 190 to 190 English acres.

On this plot of ground the retort houses are erected, and are provided with, each, a set of condensing pipes immediately adjoining the retorts, and a set of coke towers or scrubbers, and the purifiers, that are within a series of buildings parallel to the retort house. The distance from the retorts to the scrubbers may be as much as four to six miles. The retorts are set in beds of eight each, back to back; the group of eight having seven retorts in each that are double, so that the total number of retorts at work at present is about 1076; but the quantity of gas that the company makes is considerably increased by the product of the ovens, from which it obtains smoothed coke, for the coke tower, and burnt the retorts are set in beds of eight each, back to back; the group of eight having seven retorts in each that are double, so that the total number of retorts at work at present is about 1076; but the quantity of gas that the company makes is considerably increased by the product of the ovens, from which it obtains smoothed coke, for the coke tower, and burnt the

The style of retort used is a clay retort, of the usual D shape, that is about 8 ft. 2½ in. long, by 2 ft. 4 in. wide, and 1 ft. high in the clear; and it is to be observed that the French engineers prefer the use of the closed retort over the fire-clay ovens to that open at both ends (as in some of the London companies' works), for they contend that it is impossible to maintain an equal temperature in the ascending mains that must be used in the latter case, so that the gas escapes up one of these, to the detriment of the illuminating power, or to the destruction of the dip pipe, according to the temperature. The gas in the Paris works passes from the retorts to the hydraulic main, and thence through a set of condensing pipes, that are placed outside the building, in sets of three rows of ten pipes each, to the set of double retorts. An exhaust here takes the gas, and thus relieves the retorts of the back pressure; this exhaust is set in motion by a steam engine of 16 horse-power. There is a second machine for the purpose of relieving the pressure upon the gas, and the exhaust is used for special arrangements for condensation, purification, &c., to be noticed hereafter, and quite distinct from the ordinary service of the gas factory. The exhaust takes the gas from the condensers, which are made particularly large, so as to effect the greatest possible amount of condensation (which the French engineers attach great importance to); in the process of condensation and the purification of the gas, and passes it to the scrubbers and the purifiers. In the scrubbers, or the coke towers, the gas is subjected to a system of washing, for the purpose of extracting as much as possible the ammoniacal liquor, the tar, and the sulphur compounds, that it may still retain; and then passes, without any intermediate process of washing, to the purifiers, where it is exposed to the effects of a mixture of sulphuret of iron, lime slaked and in powder, and sawdust, in the proportions of 1 metre cube (about 1½ yard cube) of sawdust to 010 metre cube of lime in powder, with about 2 cwt. of sulphuret of iron. This mixture is found to be preferable for the purification, as it is capable of being kept in a state of readiness, and is used at once in the factory, because there the agricultural interest does not appreciate the employment of the lime refuse of the purifiers. The gas here is passed through four successive layers, or rather series of layers, of the description given above, and is then passed through the system meter to the gas-holder, where it is stored for distribution.

There appear to be differences of opinion amongst the Paris engineers with respect to the conditions of the distillation of their coal, and with respect to the methods to be adopted to prevent the formation of the sulphide of carbon in the gas. The present practice of the gas company is, however, that of effecting the distillation with great rapidity and at great heat, and combating the tendency of the gas to the formation of the sulphide of carbon by means of a more energetic condensation. The charges that are generally employed are four-hour charges, at high initial temperatures, of about half a ton each retort; the French engineers attach great importance to, of methods of ensuring the 9300 to 9500 cubic feet of gas (which is more than the London companies on the average do from the superior coal of Newcastle), and about 13 cwt. of good marketable coke per ton. The proportion of condensing surface that is found necessary under the French system of replacing the washing by an energetic condensation is too small, in the opinion of the engineers, to allow of the gas being forced to bubble through a solution of ammoniacal liquor after it had passed through the coke towers, and now this process is dispensed with, so far as regards the passage of the gas through the ammoniacal liquor. The gas passes through the meter station, and from thence it passes into the gasholders preparatory to the distribution; these are eight in number at the station of La Villette; they are 107 feet in diameter, and 46 feet rise in a single lift, and are supported by a scaffold in the centre when down. The distribution of the gas from these reservoirs takes place under the pressure of rather more than 1½ inch during the day time, and in the night time the pressure drops to a fraction of this. It may be required to overcome the difference of level of the factory, which is somewhat above the points of delivery in Paris; or it may be accounted for by the small dimensions of the distributing mains. The efforts of the company are, however, directed to the remediying this cause of loss, which must always, and cannot be entirely prevented, to say with regard to the mains of distribution and the quantity of gas they would discharge in a given period of time being observed, owing to the interest the company have to continue their working through the pipes that they are bound to yield to the town at the expiration of their lease. By the peculiar arrangements adopted, the Paris Gas Company has reduced the losses that ensues from the excessive pressure that accompanies the distribution of the gas to a minimum. We shall have occasion to revert to this subject; but it may be as well to state that the loss of the gas registered by the station meters, both in private consumption and in public lighting, is about 30 per cent. The expectation is that, if the proportion, if the quantity that is lost by the condensation in the mains, the amount that is not carried to account by the private consumers, and the thousand causes of loss that the gas must be exposed to, are taken into account. The average loss of the London gas companies is at least from 15 to 25 per cent. of the quantity of gas which is supplied to them. There are at La Villette numerous contrivances for the preparation of marketable coke, that are well worthy of attention, but which is not worth while to describe at present, inasmuch as the care with which this branch of the manufacture is conducted is essentially a local necessity, called for by the habits of the people, and in matters of this kind is not to be lightly considered.

There is, no doubt, immense skill displayed in this detail of the Paris fabrication, but it may be passed over, together with the brick, tile, and retort factory that forms an important part of the establishment at La Villette, and which manufactures for all the other stations in Paris. In Paris the gas company had, in fact, to organise every detail of the service, and to create the industries that are connected with the working of the factories. The Paris gas company is an example, for the making of the gas; they, therefore, were deprived of the advantages that the English companies possess in the greater division of labour that prevails in this country, and which permits them to concentrate all their attention upon the strict object for which they are established. The coke manufacture cited as a proof of the above

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

The distribution of gas takes place through mains that are of as large a diameter as 3½ feet, exactly one metre; they are all of wrought-iron, upon Chameroy's patent, and in that respect the Paris supply differs from that of London, which, in consequence of Mr. Michael and Angelo Taylor's Act, is compelled to receive gas under iron or cast-iron mains. The Chameroy's pipes are put together in lengths of 15 or 16 feet; the joints are screwed and brazed; the whole is then coated with a preserving coat of bitumen, and the joints are made with a malleable screw on one end and a thickening out, formed on a mandril, to receive a female screw on the other, which is then packed with gasket and white lead. The opinions of English observers are uniformly adverse to this style of pipe, but the experience of the Gas Company of Paris for the last twenty-seven years seems to decide as to its merits in all cases where the soil is of an alkaline nature, and is not charged with water. I was informed by M. Camus, the superintendent of the Gas Company, that in the case of the Chaussees, that he had ascertained the wear and tear of 1000 metres of wrought and cast iron mains of the same diameter respectively, in the course of the year 1861, and he found that they presented the following results. He found that the cast-iron showed that the proportion of the leakage that was owing to accidental breakage in the pipes was 1½ per cent; whilst that quantity was, for the wrought-iron, 0.490; the proportion of loss through the use of the pipes by time or depreciation was, for cast-iron 0.335, for wrought-iron 0.198; the proportion of loss by shaking of joint was, for the cast-iron pipes 1.77, for the wrought-iron 0.029. There may be greater care and attention paid to the cast-iron pipes, and may be the result of the experiments tried in this case seem to indicate that the cause of the diminished loss upon the registered quantity of gas must be sought for in the use of these mains; and at the present day, when so much attention is forcibly turned to the question of the leakage of gas pipes, on account of the construction of subways by the Metropolitan Board of Works, the subject acquires additional interest. The house distribution also takes place in Paris through lead service pipes, that must be another cause of diminished leakage; but the private consumer is at liberty to employ whatever system he may think proper after the passage of the gas through the metre. From the report of the Royal Technical Institute of Mining and Metallurgy of the year 1861, it appears that the total consumption of gas in Paris was about 3567 millions of cubic feet, for a population that was estimated at 1,650,000; and the company had, in their provision of an increased demand, increased their manufacturing powers to 1441 millions. The length of pipes that were employed in the lighting of Paris was 510,000 metres; at the end of the second year, 442,000 metres; that of the boulevards, and the surrounding district, 165,000. The number of public lights supplied by the company for the account of the municipality was 26,849; the number of private consumers was 99,554, in the year 1863, the last for which I have been able to procure the returns. It may be added that the pipes that are used for the lighting of the Boulevards are placed at distances of 25 metres apart on the same line; in the Rue de Rivoli they are about 14 feet apart; in the courtyard of the Louvre they are about 20 feet apart; the burners being, in the majority of cases, at 10 feet above the pavement. The lighting of Paris is one of the most brilliant and lavishly executed, in the best quarters of the town at least; it leaves, however, much to be desired in the poorer portions, which are about as badly lighted as the analogous parts of London.

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

The Paris Gas Company is managed, as all the important operations of that country are, by a board of directors; the administration is composed of a certain number of directors, who are chosen from the body of the shareholders, generally speaking from amongst the original proprietors in the various gas companies that were amalgamated together, and they are assisted in the management by M. Gayfier, ingénieur-général of the Paris Lighting Company, who is an observant and incisive man, and a director of the company, that body, who have under their orders a numerous staff of engineers, chemists, practical men, and clerks, that would frighten any English board of management. Thus the expenses of the salaries to the various people employed in the factories, in the maintenance and laying of the mains, and in the office of the company, was but 100,000 francs in the course of the year 1863; but at this charge the service is performed with a degree of perfection that we in England have no conception of. The cost of every detail of the manufacture is known to the latent century; the waste that attends the operations of the London companies is unknown; the accounts are kept in the most elaborate manner, and the directors, and their own servants with a liberality that we in England have no conception of. The result of the system is, that in Paris the gas works is not managed at about 55 per cent. of the total receipts; which may be accounted for by the fact of the great success of the speculation that the directors manage, and by their having no inducement to introduce any great economy in their working, in consequence...
the participation of the town in the profits of their concern after a certain time. There is, indeed, every inducement for the directors to indulge in expense in the management; none to induce them to save; and as the city of Paris has also a direct interest in knowing the cost of every detail of the fabrication of gas, it is questionable whether at any time the fraise d'administration and deontic, or the two names, will decrease. It is certain, that the Paris Gas Company is managed with consummate skill; and though we in England would do very unwisely, as I think, to adopt the system that prevails in the neighboring capital with regard to the supply of gas—because it is founded upon principles of political economy which are, I think, wrong, and it is an instance of what our private liberty, which I think would be intolerable—yet there are many things that seem to be well deserving our study, and our imitation, in the manner the Paris Gas Company carries out its contract. The system at Paris is, in fact, designed for the atmosphere of France; it would fail if introduced here, where "every man does what he likes in his own eyes."

In the discussion upon the foregoing paper, Mr. Gurney Gower said he was not able himself to agree with what appeared to be the leading object in the paper, viz., to make us more satisfied with what was done for us in England. It was not likely that Englishmen would put up with such an arrangement as was made for the inhabitants of Paris. The notion of tying themselves down for fifty years to take their gas at 5s. 9d. per 1000 feet (with allowances and deductions), not with an intention to make a large profit but with an intention of making as little profit as possible, seemed unreasonable. The people of Paris at that moment paid very little more for their light than in London. He was assured that the light there was much superior. It was true the municipality of Paris partook of an advantage to the extent of 5s. 9d. per 1000 feet, and divided the profits beyond 10 per cent, after sixteen years. They had an assurance with them, and an interest with them, which we have no assurance with. It was not likely that we should permit such an arrangement; although we were, perhaps, not much better off with our arrangement than the Paris people. He regarded it as idle to say that the escape of gas could not be guarded against. They were told that the escape from the mains was still very great, as was manifest from the state of the soil round the joint of an old gas pipe; the loss to the companies was great; the damage to health would be great, by-and-by; and in order that they might go on laying down pipes with bad joints and other careless arrangements, they brought forward the evidence of one solitary French engineer, to prove that the escape was 3 per cent. Of pipes being laid in subways. In the case of Nottingham the system had been carried out without damage, and he was satisfied that this plan was a perfectly practicable one, and it would be a disgrace to the companies if they persisted in opposing its adoption. In many buildings he had seen as much as half a-mile of pipes of iron, and sometimes more than a day without any ventilation through the joints. But there was no escape of gas, because the joints were properly made. He was satisfied if the gas mains were laid in the subways, and a proper system of ventilation provided, no better plan could be adopted. At present the public were subject to the perennial annoyance of disturbances of the streets. All that annoyance might be avoided by using the subways; and, notwithstanding Mr. Burrell's endeavours, they must persist in pressing this matter on the attention of the gas companies; and if they would not afford the public redress, it was to be hoped that the legislature would do so.

Mr. THOMAS HAWKESLEY entirely disagreed with the gentleman who had last addressed the meeting. He (Mr. Hawkesley) had had thirty-five years' practical experience of this subject, having been the engineer of the Nottingham Gas Works, to which Mr. Godwin had alluded. He would tell them the real case. The subway at Nottingham was a little pitiful thing, of about 200 yards in length, and the gas-pipe which was in it was four inches in diameter, the street having very narrow houses, and nothing but houses, there being no other houses than that pipe. It so happened, also, that this little channel a rise in the short length he had stated of very nearly 40 feet, and consequently it ensured for itself a tolerably good ventilation. He need hardly say that these were circumstances which did not apply at all to such a place as the Metropolis. It was remarkable how great were the apprehensions of the workmen of gas company in reference to this subway, for they would not go into it unless the gas was shut off, and even then they used a safety-lamp. They were told that gas had been laid in subways, and that gas had been lighted in them without danger, but the danger was occasioned by the insidious escape of gas by leakage; and when this occurred in any confined space, an explosive combinations of gas formed, which was the origin of the disastrous effect of a disaster, particularly in a subway, where the whole street might be bodily raised up, and the passers-by would run the risk of being injured, if not killed. A good deal had been said about the escape of gas in the streets, but he would assert that it did not reach to anything like 5 per cent; in general it was much less. What was called leakage was that to which the gas company sustained upon the gas, as ascertained, in the first place by the meter at the stations, and in the second by the money which the gas company received. A thousand and one things happened between the station meter and the receipt of the money by the company. In the first place there was leakage at the works, which was very considerable. In the next place there was the consumption of gas upon the premises, which was to be counted by millions of feet a year, and which very few gas companies took into account. Then the gas went into the mains, from which there was a very slight escape indeed, and that escape passed into the soil, where it was absorbed without danger. A great deal occurred from the works reception to the mains of the company. That was a loss which ought as far as possible to be prevented; and if gas companies generally used lead pipe instead of wrought-iron for services, as was done in many places with great success, they would not suffer in this way. The gas eventually went to the meter, which professed to measure the whole of the gas that went through it, and any defect of the meter, whether wet or dry, was against the gas company. Then there was all the surreptitious and fraudulent consumption of gas, which in a great city was not incon siderable. Then, further, there was the waste in the public lamps, which was greater than any other, for this reason: each lamp was supplied with gas, and the pipe must be full of gas for that consumer as for a private consumer using ten or twenty lights, and thus there would be a greater proportion of leakage. All these things put together went by the general name of leakage, whilst the escape from the mains of a well-managed company was not more than 2 or 3 per cent. Of the Valley, of which there was no information, and any defect of the meter, over a period of three years, did not average 8 per cent, and at Nottingham, before the introduction of Lord Redesdale's Meter Act, the leakage was as low as 5 per cent; but owing to the operation of that Act it had latterly been as much as 20 per cent. Of which would happen in subways was this:—A gas company alone could not control all the operations of the subway; other workmen would be employed there who might be the occasion of accidents. If the streets of London were generally subwaysed, he had no hesitation in saying that with 2000 miles of subway, there would not be a gas pipe laid in them; and it would be impossible, in the nature of things, to prevent this. Passing to what had been said with regard to the gaslights in Paris, he would say he did not find anything better there than we had at home. The quality of the gas, the mode of manufacture, the amount of production, and the system of distribution, were in every respect inferior to what we had here, and, above all, the price of gas was 50 per cent. higher than our maximum price. The French system of political economy was the worst that could possibly be adopted. It was a system by which the municipality was bribed to participate in the profits on high prices; and the consequence was, that those who could not immediately be made to pay the taxes of those who did not do so. The same thing had been attempted, with various degrees of success, and want of success, in this country, a notable example of which existed—and to a certain extent still exists—at Manchester, but under modified circumstances. For many years the corporation of Manchester charged a very much higher price for gas than the price of the gas used in the houses, and the money so obtained was applied to municipal purposes. The consequence was, a certain portion of the community was taxed for the benefit of the other portion. For a time that system went on very well, but it ultimately gave rise to a violent class agitation, which it was always desirable to avoid. If you tax the community against the other on the price of gas, and that went on for several years, and at last resulted in the gas consumers beating the non-consumers, and then the price of gas...
was brought down to something like a reasonable amount. Paris was a much better lighted city than London, but the Paris gas in illuminating power was inferior to ours. The fact was, in Paris, the people lived, not as we did, one alongside the other, but one above the other, and the consequence was the population there was in a much shorter length of streets, and they had one lamp every sixty persons; the consequence was, that the principal streets the lights were brought very close to each other; but it did not thence follow that because the city was better lighted, the gas was better. Its inferiority was accounted for by the description of coals they used; they, nevertheless, made them burn with the circumstance, and they took care to use the kind of burner which gave the most perfect combustion. This was a matter which was neglected in London, but we were improving in that respect; and when we paid as much attention to these details as was done in Paris, the London gas would give a greater amount of light than that in Paris.

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

Mr. Gore, having had experience in the laying of gas mains in this country and abroad, was inclined to think that the promoters of the subway system were at the present moment somewhat in the dark on that question. He could quite understand that in situations where there was a sufficient current of air to carry off the escaped gas there could be no explosion, but it did not follow that in a subway the current of air would be so rapid as to have this effect. Having been engaged, in 1851, in laying down gas main in Valparaiso, he gave an example in some pipes in that city, such as at six inches below the surface of the soil granite was reached, and through that material a channel had to be chipped away of sufficient depth to admit of the gas main being laid down. Theoretically that would be supposed to form a very beautiful channel in which to lay the pipes, but a reference to the books of the company would show that the cost of repairs in that channel alone amounted to 75 per cent. more than in double the length at other parts of the town where the pipes were laid in a different material. Mr. Hawkesley had very properly said that the soil was the best safeguard against the escape of gas, and at the same time it formed the best elastic cushion on which to lay pipes. In laying pipes in a subway, there must be a number of rigid fixed points or brackets on which they must rest, and there would be a severe vibration occasioned by the traffic passing overhead; the effect of which on cast-iron mains so supported would, in a very short period, be very serious, in causing leakage at the joints. If so low an estimate be made of them to risk the present system of junction, there would be a liability to great escapes of gas. There, however, no reason why an improvement should not be made in this respect. The question was, whether iron was the proper material for the pipes, unless the interior were coated with a preservative substance; and if, besides this, a better system of joints were introduced, he had no doubt that subways might be used for gas-pipes without danger.

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

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

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

INSTITUTION OF CIVIL ENGINEERS.

President's Address.*

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

The preparation and training for the civil engineer may be shortly described as follows:—1. General instruction, or a liberal education. 2. Special education as a preparation for technical knowledge. 3. Technical knowledge. 4. Practical work. All this preparation and training will have to be acquired at some time or other, and in some order or other, and it is known that in the cases of some successful persons of great perseverance, they have been acquired in a very remarkable order; but at the present time, and with all our modern opportunities, there is no reason why they should not be learned in the most convenient and methodical manner. I will begin by supposing a boy of fourteen, in whom his parents have discovered a mechanical bias, who has made good progress in his general education, and especially in arithmetic, is of strong constitution, and possessed of considerable energy and perseverance; and unless a boy possesses these tendencies and qualifications it is quite useless to destine him for an engineer,—taking the boy of fourteen, however, who possesses the requisite qualifications, and with a determination on his own and his parents' part that he shall be made an engineer, the period from

* Concluded from page 56.
fourteen to eighteen should be devoted to the special education required by an engineer, dealing with mathematics, physics, languages, geometry and levelling, drawing, chemistry, mineralogy, geology, strength of materials, mechanical motions, and the principles of hydraulics, should be thoroughly mastered. To accomplish these studies, and, in addition, to make considerable progress in the languages and German especially, it will be necessary to sacrifice to some small extent his classical studies, to pursue mathematics; and it is, in fact, the partial omission of these studies, and the prominence of those I have enumerated, which constitute a "special education." If from fourteen to eighteen the boy has made all the progress in these studies which can be reasonably expected from fair abilities and moderate average perseverance, there may be no great importance, and is one respecting which some difference of opinion will exist.

At eighteen a boy, if duly prepared, may either be at once placed in the office of a civil engineer for a period of four or five years' pupilage, or he may be placed in a mechanical workshop, or he may be sent to one of our great mechanical schools. These may be the best under particular circumstances, such as local convenience, or as the social position of parents may dictate. It cannot be doubted that a period of twelve to twenty-four months may be very profitably spent in manufacturing works, before passing into a civil engineer's office; but in that case it is possible that the works selected are adapted in themselves to impart the desired information; and that proper organization exists for carrying out strict office discipline, regularity of attendance, and due diligence; and that assistance is given systematically to the pupil to enable him to obtain all the advantage possible from his stay at the works.

The best impression the future engineer that during his professional preparation he should continue his studies of mathematics and scientific works relating to his profession, and also of modern languages.

In the case of his being intended to send the boy to Cambridge or Oxford, it is indispensable that all preliminary professional work, and, it is well known, the knowledge of mechanics, mechanical drawing, surveying, and levelling, should be mastered before going to the university, because it can scarcely be expected that he will submit to the drudgery of learning them after his return from a three years' university course, then at the age of, say, twenty-one, probably one of the best plan universities, and any one of these courses could be taken after his scholastic studies somewhat earlier than eighteen, if it be intended that he should go to the university, and to take especial pains to make him accomplished in the preliminary work of the draughtsman, the surveyor, and the mechanic; so that when he has taken his degree, and enters as a pupil in a civil engineer's office, he will at once commence useful and independent work of his technical studies somewhat earlier than eighteen, if it be intended that he should go to the university, and to take especial pains to make him accomplished in the preliminary work of the draughtsman, the surveyor, and the mechanic; so that when he has taken his degree, and enters as a pupil in a civil engineer's office, he will at once commence useful and independent work of his technical studies; and if from the age of seventeen or eighteen he does justice to his opportunities in a good workshop, keeps up his knowledge of the modern languages, proceeds to Cambridge or Oxford, taking a good degree, and afterwards completes his studies as a pupil with a civil engineer, probably such a course would constitute the best possible preparation and training which could be obtained; but at the same time it cannot be doubted that it is a somewhat hazardous combination, and can only be successful with great determination on the part of failure or success will depend on the degree of diligence with which he avails himself of the opportunities of acquiring knowledge during his pupilage. The work in the office and in the field should be done to the best of his ability, and after the pupil has become a skillful draughtsman, and is capable of taking out quantities of engineering works, and preparing detailed estimates methodically arranged, he will then probably proceed to work out details of designs, and make calculations of strengths and strains, and thus become of real value in the office, at the same time making substantial progress and rapid improvement for himself. He should avail himself of every opportunity to study; and the engineer, in the construction of the work brought to his notice both in the office and in execution; he should ascertain the cost price of all the materials and workmanship employed, separating the items into every minute detail; and he should continue this practice systematically with all works on which he is engaged.

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

The information or knowledge included in this brief enumeration may be called practical knowledge; and it cannot be too often urged upon young engineers that theory and practice must always go together, hand in hand, and that they are not only not incompatible, but that the practical studies may be amplified, and must both be fully developed in the same person before he can become a properly qualified civil engineer. The period of pupilage should be from three to five years, depending on the circumstances which have been previously indicated, and, in addition to his attention to the office, and outdoor works, it will be well for the keeping of accounts, and special study of mathematics, that he should improve his acquaintance with the French and German languages, and keep up his knowledge of their engineering literature, and also avail himself professionally and personally of the advantages offered by this Institution. In the case of the mechanical engineer, however, it will be seen that although all scholastic and scientific training should be the same
as that previously described for all other branches, the period of pupillage of the mechanical engineer must necessarily be passed during the first ten years of his career. The first ten years in this case, the forty-eighth year of its existence, that when it had been established twenty-four years, the number of members was almost exactly one-half of the present number.

The experience of the last few sessions shows us clearly that we may expect the future rate of increase to be at least equal to the past; and the attendance on the Tuesday evening's discussions shows an increase year by year, and in the forty-eighth year of its existence, that when it had been established twenty-four years, the number of members was almost exactly one-half of the present number.

It will thus be seen that a steady annual increase has been the characteristic of the Institution from its commencement; and it may be said that the interest attached to the proceedings of the Institution increases in at least an equal proportion with the augmentation of the numbers. It is not now uncommon to find our meeting-hall inconveniently crowded, and occasionally it is altogether inadequate to accommodate the members who desire to be present; and many persons who, from the public interest attached to some of the subjects, desire to hear, or take some of the discussions, are now prevented by our restricted accommodation from doing so.

For some years in the early history of the Institution it was a work of considerable difficulty to keep the disbursements within the receipts, and except for the considerable management of our late Secretary and his Honorary Secretary, Mr. Murray, it is hard to know what difficulties we might not have experienced; it was not until its income became sufficiently increased by the liberal donations of the council and other members, by the increased subscriptions of the Institution, and the increased accommodation and assistance to its members. It may be stated that during the last ten years the average increase on the receipts has been forty per cent, whilst the increase in the disbursements has been only twenty per cent; and that the present amount of the realised property of the Institution may be safely taken at £2,000.

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

Most of the members of the Institution are necessarily engaged in their ordinary daily professional duties during the only hours when the library is at present available to them; and it if obvious that it is only in the case of a special reference being required, or for some statistical purpose, that the library can be useful to members generally under the present arrangement. I can say from my own experience, that I should have felt it a great advantage to have had a reading room, or a place for spending an occasional evening in the library, and of reading and consulting the rich card of professional learning and experience now collected there, and therefore I throw out this hint respecting the extension of the hours for reading.
specifications to which they have had access in the library. I would also venture to suggest that, in addition to the greater advantages which may be conferred on those using the library by extended time of access to it, and to the collection of working drawings and specifications, with arrangements for inspection of practical works, a limited number of lectures would be very valuable, if given by members who were especially conversant with any given subject, on other evenings than those of the ordinary meetings during the session of the Institution.

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

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

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

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

January 30th.—The first paper read was on “The Craggischla Viaduct.” By W. H. Mills, M. Inst. C.E.

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

It was stated that the Spey was one of the largest and most rapid rivers in Scotland, and was also subject to sudden and heavy floods, the water sometimes rising 6, 8, or 10 feet in as many hours. It was about 110 miles in length, took its rise amongst the Grampian range, at an altitude of upwards of 1190 feet above the sea level, and for 10 miles above the viaduct, which was situated 15 miles from the sea, its average fall was 14 feet per mile. No part of the river was navigable for boats, but it was much used for the conveyance of timber, which was floated down the river.

In designing this viaduct, it was necessary to provide an uninterrupted channel for the free passage of rafts, and to construct the piers and abutments so as to be able to withstand the blows and pressure from any remarkable change in water level, at down during floods. The channel of the river was about 100 feet wide, and 180 feet broad, and 4 feet deep in the centre. The height to the underside of the girders from the usual water-level was 20 feet. The bed of the river consisted of coarse gravel interspersed with large irregular boulders, overlaying a compact layer of gravel and clay. A timber pile construction, could not therefore, be advantageously employed, and it was decided to use cast-iron cylinder foundations for the main pier, small river pier, and abutments, and thick beds of concrete for the small land pier and abutments. The cylinders in the main pier and abutments were 5 feet in diameter, and in the small river pier 4 ft. 3 in. in diameter. They were in two equal lengths, and formed, when belted together, one complete cylinder 18 ft. 6 in. in length. Their size was sufficient to allow a man to stand upright in the cylinder, and broke, when knocked by the council, and removed in pieces, with the excavated material. The operation of sinking the cylinders was carried on night and day, generally with four or five at the same time, and so expeditiously that the eighteen cylinders used for the main pier were fixed and filled with concrete in ninety days. The fifteen cylinders in the main abutment, where a larger force was employed, in three weeks. There were eleven cylinders in the small river pier, and, in all cases, the lower edges of the cylinders were 13 ft. 6 in. below the bed of the river.

The general arrangement of the plates, angle irons, and T-irons of the lattice girders provided for a free circulation of air to all the ironwork, facility for getting at the works for cleaning and painting, and avoiding any opportunity for the lodgment of water or snow. These girders were provided in such a manner, that in each main pier, and took part in the work. A single piece of the lattice girders was used for each girder, consisting of angle irons varying in section according to position and relative strain. The main girders were 17 feet apart from centre to centre, and they carried the railway on the lower flanges. The cylinders in the main pier and abutments were 4 feet apart, the rails being of wrought-iron bolted to the cross girders. The lattice girders were held together laterally by five wrought-iron strainers, securely fastened to the main girders at the top, bottom, and sides. The lattice girders and the plate girders for the main pier were each connected with the lattice girders at the altitude 8 feet above the bed of the river by means of thus one continuous system. At the main pier the girders were bolted down to the masonry, whilst at the other piers and at the abutments the girders rested upon turned cast-iron rollers.

The results of several experiments showed that the average breaking weight of the plates was 22.39 tons per square inch, and of the angle iron 24.16 tons per square inch. At the Government inspection, with a moving load equal to 1 ton per lineal foot, the deflection of the main girder was only 6 inches, and that of the cross girders was of wrought-iron 15 feet apart, the rails being of wrought-iron bolted to the cross girders. The effective sectional area of the bottom member, deducting for cover plates, rivets, &c., was 70 square inches, giving a tensile strain of 4-1 tons per square inch. The effective section of the upper member, without deducting for cover plates, was 75-74 square inches, which gave a compressive strain of 3-77 tons per square inch.

The total quantity of materials used in, the time occupied in the execution of, and the actual cost of the different portions of the work, were given in detail. It appeared that the excavation of the foundations was done in May 1846, and the viaduct was opened for traffic in July 1848. The total cost had amounted to £12,199, or equal to £27 10s. per lineal foot.

The second paper read was on “The Grampian Viaduct, Mauritian Bridges.” By W. Ritning.

It was stated that the length of this viaduct, from abutment to abutment, was 620 feet, and that this distance was divided into five openings of 110 feet each in the clear. The height from the level of the rails to the surface of the water was 229 feet 9 in. Each pier was composed of two cast-iron cylinders, each 10 feet in diameter, resting upon masonry foundations, and covered with concrete; the works being for a single line of railway. Mr. Hawkesworth (Past President, Inst. C.E.) was the consulting engineer to the Government of Mauritius, and the contractors for these railways were Messrs. Bransby, & Co., for whom Mr. Longfellow (M. Inst. C.E.) acted as resident agent. In constructing the piers of this viaduct, cylindrical rings 9 feet high were divided into...
The abutment on the Port Louis side was built upon hard tufts, and No. 1 pier rested upon them. In order to prevent any settlement of the pier, it was 12 feet long, the lower 4 feet resting on all sides on the tufts, and then the upper 8 feet were framed in wood, and tied to the abutment blocks by iron. The whole was then covered with a layer of concrete, and placed on the pier. The pier was 12 feet long, and 8 feet wide, and the piers were 4 feet thick. The whole was then covered with a layer of concrete, and placed on the pier.

The launching of the girders was accomplished by means of powerful tackle and winches, and was so effective that in one day the girders were all placed in position and ready for loading. The last span was launched in six hours, and the last span was completed in six hours and twenty minutes, the entire length of the girders, 630 feet, moving quite freely. The roadway girders, plates, and permanent way were then laid, and in fourteen days after the launching of the last span the work was completed. The girders fixed to the centre pier, while they rested upon rollers at the other piers and at the abutments, and so were free to expand and contract. The total weight of the superstructure was 360 tons, of which the roadway weighed 147 tons; and the total weight of ironwork in the piers, including the expansion rollers, &c., was 93 tons.

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

In this paper the author proposed to supply what he conceived to be a want in the records of the Institution, the details of the arrangements of the principal sheds and stations, particularly of a class which might be called "terminal-intermediate," and "as a combination of both kinds, such as that at New-street, Birmingham, as well as of goods yards, wharves and depots, and locomotive and railway sheds, many of which, it is to be regretted, had not been dwelt upon in the comprehensive communication "On the Arrangement and Distribution of Railway Stations," by Mr. R. J. Hooe, (M. Inst. C.E.) read at the Institution in the session 1870-1. Published in the "Proceedings of the Victoria Station Fumilo, for the C.E.," Vol. xvii., pp. 449-451. For this purpose the plans of the following existing stations, &c., were illustrated and described, as they were believed to embody the leading principles and requirements involved in the construction of such stations as the Victoria Station, Fumilo, for the C.E., and the Great Northern Railway; the shops at Battersea, connected with the London, Chatham and Dover Railway; and the rail-way Carriage and Wagon factories at Meaux, Brown, Marshall Co., at Birmingham.

The author considered, that at terminal, terminal-intermediate, and junction stations, the through and the local traffic should be kept distinct; that excursion traffic should not be allowed to interfere with the regular traffic, and especially for the local trains; and that the through traffic at terminal and junction stations should be at least 30 feet wide, and for the local traffic, docks, with separate lines of rails, could, if desired be taken out of the extreme ends of those platforms, as at King's-cross; that the in and out parcel stations should be at the head of the platforms forth, and the carriage entrances, as at King's-cross and at Paddington; that the position of the London and South Western Railway, at Paddington would be found to be convenient; that all these stations, &c., should be well ventilated, and be designed to perform the maximum of work with the minimum of water, close to being arranged to flush both on the opening and the opening of the doors, and glazed basins being preferable to plate for urinals, and that lavatories should be provided at all terminal and junction stations, as at Perth, even if a small change were made for their use, which was not however the case in the instance cited.

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

The engine and running sheds should be devised to facilitate the ready admission and exit of engines, as well as for overhauling, cleansing, and the examination of them when the shed was required. The sheds should be kept clean and dry, and have plenty of light, and space for the passage of men between the walls and the engines. The engine pits should be paved and well drained, and there ought to be similar pits outside the sheds for rough and dirty work. The supply of water, when required, could be obtained by means of hydrants, &c., was necessary for cleansing and washing out the engine boilers where over the pits in the sheds. Lifting shears and overhead traversers were deemed to be superior to jacks, and the waste heat from the engine was used to heat the water in the boilers of the locomotives, as well as for heating the sheds during the winter months. The coke platforms and the water cranes should be at the sides of the lines into or out of the sheds, so as to be accessible without shunting the sheds.

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

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

The New Street Station at Birmingham was an intermediate one for the London and North-Western and the Midland railways, and a terminal one for the Stour Valley. There were two main lines through the centre of the station, and the platforms were approached by sidings, so that the through traffic need not be interrupted. The station was situated in a cutting between two tunnels, and was so close to one, that the points for parting the trains were within the mouth of the tunnel, leading frequently to delay. The roof was in one span, and a considerable height from the ground. The various sidings, engine shed, engine shed, repairing sheds, stores, stables, and all the necessary offices for conducting the large goods and mineral traffic of that line. The Midland Railway had also a goods warehouse, and a circular running shed with good lighting. The Great Northern station was nearly in the centre of the yard, and there were fourteen lines of way running into it, with a platform on each side for the reception and dispatch of goods, space being reserved outside these, but still within the building, for the vans engaged in collecting and distributing the goods. The outer lines next the platforms were used, one, on the east side, for unloading the trucks with the inward goods, and the other on the west side, for the loading of the outward goods. The inner lines nearest to these were used for the arrival goods trains, and for empty trucks and making up trains for departure. After the trucks were unloaded they were taken by means of a turn-table and through cross roads to the depots, and when the sheds as required, were loaded and dispatched. There were great facilities for the rapid dispatch of goods, both inwards and outwards. The goods were entirely under shelter, could be unloaded, loaded, and dispatched without the use of a locomotive in shunting, except at certain seasons when the traffic was very heavy. Hydraulic power was employed for working the cranes, and at all large stations it was found to be economical in every respect. The stables were under the platforms, by which a great saving of space was effected. The goods shed was approached by two lines through the centre of that shed, and by two other lines, one on each side of the former, being reserved for full trucks. After being unloaded the empty trucks were removed by two lines, one on each outer side of the goods shed. There was a water communication between the granary and the goods shed and the Regent's-canal, so that lighters could receive or discharge their freighta direct from or into these buildings. On the west side of the goods shed the coal depôts and stables, and a coal and stone dock also connected with the Regent's canal. In front of the repair shed, with branches on the various lines in the sidings, and on the southern and eastern sides of the goods shed, and on the north in the carriage sheds. The running shed was placed in the centre of the fan, in front of the repair shed, with which it communicated by means of a through line, connected with the repair shed by a turn-tray.

The locomotive workshops of the London, Chatham, and Dover Railway, at Stewart's-lane, were conveniently arranged with a view to the saving of labour, but were not so extensive as those at Crewe, Wootton, or Doncaster. A single line of rails led to the engine shed, with the various sidings on the west side of the shed, the large central hall, from which access was gained to two departure platforms, one on either side. As the trains were started indiscriminately from both, it was submitted that this plan must lead to confusion. The great length of the platform was a good feature, but the lowness of the roof was objectionable, and the frequent supporting columns necessitated many turn-tables. The disadvantage of this arrangement was that, should the turn-table get out of order, all the engines then in the shed would be punted up until the defect was remedied. At the back of the running shed was a repairing shop, with smithy, engine and boiler house, etc.

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

The relative merits of the three kinds of engine and running sheds, the rectangular, the circular, and the radial or fan-shape, were then considered. The latter system required great space, but by placing the running shed in the centre, in front of the repairing shed, the area was utilised. Another disadvantage was that all the engines must pass over a pair of points, by which means there was a single turn-table in the centre of the shed. To guard against delays from accidents, a few engines in steam should always be kept at the terminus. The accommodation afforded by the rectangular building in the centre of the way, and to that provided by the circular, was considered by the latter was nearly only third what the former was. The rectangular required a greater amount of permanent way, but the building was less costly. The only advantage the semi-circular possessed over the circular shed was that a portion of the radius only was covered, whilst a greater length of extra road was required between the turn-table and the shed.

**THE CONSTRUCTION OF IRON VESSELS.**

**By James Llall, Jun.**

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

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

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

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

Drilling, on the other hand, has the decided advantage of being accomplished with the minimum deterioration to the plates. This fact has been borne out "in a series of experiments made many years ago by Gilbert. Each of the inner surfaces of the rivets, of seven specimens was reduced from 52,426 lb. per square inch before punching, to 41,590 lb. per square inch of solid iron left between the holes after punching, more than 28 percent, of the strength of the iron being destroyed by punching, a loss distinct from that of the metal actually punched out."

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

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

Now this panting action at the ends of small vessels, is principally confined to that class which requires to be immersed to a considerable depth in a rising wave, before displacing a sufficient volume of water to become buoyant, and as it is this immersion with its alternate releases which greatly augments this panting action, intensified by the high speed at which the vessel is going, it is requisite that this weakness be met, and the working prevented by placing material of a suitable form, and capable of uniting and extending over that portion of the vessel subject to the action complained of. The fuller vessel, although able to carry more in the ends, has, with the increased capacity, a greater displacement and consequent buoyancy, and therefore cannot be immersed to so great a depth as her finer opponent, but will not be subjected to the frequent tremors that are experienced by the other; besides, the rounded form of her ends is better suited to bear a greater lateral strain with less injury to her structural properties. It might, therefore, be questioned whether, with the same or even less lateral stiffening in the ends, the fuller vessel could not perform her work through a given time with less work done from frictional loss in water, than the other; besides, the rounded form of her ends is better suited to bear a greater lateral strain with less injury to her structural properties. It might, therefore, be questioned whether, with the same or even less lateral stiffening in the ends, the fuller vessel could not perform her work through a given time with less work done from frictional loss in water, than the other; besides, the rounded form of her ends is better suited to bear a greater lateral strain with less injury to her structural properties.

The strain which exposes the great weakness in long iron vessels is that to which they are subjected when accidentally caught in the middle or by the ends, with the greater part unsupported, as in the narrow part of a river or on a submerged bank or rock, or when one of the ends, for a considerable length, may be overhung in a place where there is not at all times sufficient water to float the suspended part, and prevent the strain, due to the weight of that part with the cargo it contains, and its length, affecting the upper works of the vessel. These are very frequent occurrences, it is true, but is it not the duty of the naval constructor to anticipate—so far as the power of reason will allow—such emergencies?

The strain—which although of a shorter duration—are the same when the vessel is "pitching" and "squeeling" in a heavy sea, and perhaps, for the duration of each rise and fall, are far more severe,—the strain which is produced by the weight and length of the suspended part, and the cargo it contains, agitating now a vertical, now a horizontal wave, is which it is raised, and the sudden shocks met with in its descent.

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

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

Mr. John Vernon, in a very elaborate paper on this subject, read before the Institution of Mechanical Engineers at Liverpool in 1833, showed that the strength of an iron ship of 1300 tons, built to take the highest class obtainable, was sufficiently strong to enable her to meet any of the above emergencies without being injured. To take the same example as that adduced by Mr. Vernon; and first, let the vessel be resting by the ends, with the middle unsupported, and the distance between the supports as given, 165 feet. The sectional area in tension, which is made up on the assumption that all the strakes of side plating are arranged as in Fig. 23, and their effect found by finding the "distances from the neutral axis," is "547 square inches." The weight of the ship is "758 tons," that of the cargo "1945 tons," making a total amount of "2703 tons." The length unsupported being divided into 14 equal portions, the respective cargo capacities or loads of these are in the proportions of 11, 20, 23, 24, 23, 14 respectively, proceeding from the Stern to the bow. The result obtained by taking a mean effect of these several loads at the centre of the vessel, is that the strain produced at the centre by the distributed load amounts in this case to 74 per cent. of the total load instead of 50 per cent., or one half the load as would have been the case if the distribution of the load had been uniform. Let us take the entire mass of the vessel 1819 tons, 909 tons, acting at each end by tension on the lower part of the vessel, with a leverage of 924 feet, or half the length of the unsupported portion of the vessel! Following this up, we have 909 tons, the weight acting at each end by tension into 924 feet, the distance at which this load is supposed to act from the centre, equal to the half of the mass of the ship, is "547 square inches," at a distance of "9 feet" from the neutral axis. Now, a double riveted joint is only equal to about 14 tons per square inch of section when the plates are of a quality capable of bearing 20 tons per square inch, and as the vessel under consideration only has double riveted, the value of each square inch of section must be allowed to be the same as that of double riveted joint. We have, therefore, 547 square inches, into 14 tons, into 9 feet, equal to a resistance of 68,932 tons; but showing a deficiency of 51603 tons, or about 369 square inches, at the same value—14 tons per square inch—and this, after the side already found to be 924 feet at the angle at which the beam is inclined at the end resting in the middle; using the same data as Mr. Vernon, we have the load at the end of the vessel amounting to only 44 per cent. of the total load, instead of 50 per cent., or one half as much as would have been the case if the load had been uniformly distributed through the vessel. With a whole weight carried, which is 1945 tons, we have 858 tons, in addition to which there is the whole weight of the vessel, one half of which acts in conjunction with 44 per cent. of the whole load, or 856 tons, making a total of 1356 tons, or one half of which, or 678 tons, is acting at each end by tension upon the upper works of the vessel. Let us, therefore, suppose a strain of 924 feet from the centre upon each end, by which a strain of 57,118 tons will be produced. This, as before, is obtained by the load 617·5 tons into the distance at which it acts from the centre of the vessel to be resisted by "275 square inches"—obtained as before in the bottom part into 16 feet—the distance from the central axis, which, taken as before at 14 tons per square inch for double rivetting, gives 275 × 14 × 16l, equal to about 62,562 tons, showing 5444 tons above what is required for such an emergency; but this 275 square inches of section includes the side plates from the neutral axis, as well as the stringers, ties, and angles of both decks, and the sheer strakes. Where the centre of strain is not the centre of gravity of the material intended to resist that strain, the latter never can import its full value to the structure of which it forms a part. Hence it will be objectionable to include the vertical plates on the side of a vessel below a given depth under the main or other deck under which the principal fastening is, and above a given height over the keel in any subject of ordinary dimension.

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

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

As the value of any tie is proportional to the sectional area of the rivets uniting it to the parts tied by it, it would appear unnecessary to tie the deck or any other part of a vessel by side strakes, by the lower stringer placed at the angle of the beams, or parallel to the length of the vessel. If the sectional area of the rivets by which the ties or bracing are united to the beams are equal, and extend over a certain part of their length, which might not, therefore, the material used as diagonals be annexed to the present tie plates, and united with them in over-
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL. [March 1, 1866.

coming any tensile strain to which the upper works may be exposed, and at the same time overcome the zigzag action imputed to iron vessels? If this view be a correct one its adoption would give more satisfactory results, with less cost than can be obtained by the present use of diagonals.

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

THE ARCHITECTURAL ASSOCIATION. (Meeting held 16th February, 1865.)

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

ON POINTS OF ESSENTIAL DIFFERENCE BETWEEN CREATIVE AND IMITATIVE ART.

By J. T. Lyon.

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

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

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

In a similar manner, when we are beautifying a surface by cutting or painting geometrical figures upon it, we are ornamenting by simply creating, when we cut or paint forms upon the surface of another material, we are creating by simply imitating; we are ornamenting by both creating and imitating, and when we carve or paint these forms exactly as we see them in nature, we are ornamenting by simply imitating.

It is perhaps necessary before proceeding further to offer some explanation of my meaning of the term "Creative Art." We may say, not the literal meaning of the word "create," that it is impossible for man to create anything, as much as it is impossible for him to destroy anything; but the word is a convenient one to express that originality of thought and formation which to the mind and eye are certainly original. The "common acceptance of the term "creative art" implies that degree of sentiment, idea, or as Shakespeare expresses it, "creation of the mind," which a pictorial artist throws into his picture. This, without doubt, is the highest manifestation of the term, so high, that, as Mr. Ruskin has well shown, the actual formation of the object upon the canvas is quite secondary to the idea which is conveyed.

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

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

I will take this opportunity of quoting a passage from a book entitled 'Recreations of a Country Parson,' to show that even in the very smallest things we should pay due attention to order. The chapter is "Concerning Tidiness." The Order says, says the writer, "is Heaven's first law, and there is a sensible pleasure attending the carrying of it out faithfully to the very smallest things. Tidiness is nothing else than the carrying into the hundreds of"
Nos. 1, 2 & 3. From the Nave of the Cathedral at Angoulême.

Nos. 4 & 5. From the Church of S. Front Pèrigueux.
little matters which meet us and touch us hour by hour, the same grand principle which directs the sublimest magnitudes and affairs of the universe." The writer goes on to show how a love for order is inherent in every good mind. I have said this much concerning order, because it would seem to be a law, that every art-object which man constructs or creates by the simple working of his mind, from the most sublime architectural edifice, down to the most insignificant child's toy, ought to be made with due regard to order.

This order, then, is the first essential of pure creative art. In pure imitative art the case is reversed. We then copy nature as she naturally appears to us, and as we have seen that she naturally appears to us, not disorderly, but in its essential the essence of imitative art. Even the term picturesque, as applied to the imitation of nature, means that amount of "admired disorder" which is the great charm of a picture. We have then one point of essential difference between creative and imitative art: the former is symmetrical and orderly, the latter unsymmetrical and disorderly.

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

I have observed that a principle of order should always accompany our constructed works of art. We see this principle carried out to its extreme in the art of building. In the fluted column, the moulded pillar, in the graceful leaves of the Corinthian capital springing from their parent trunk with mathematical accuracy, and even the naturally carved foliage of the Gothic capital, however wayward and fanciful, is bound, in good architecture, to some defined and well-ordered line of beauty, so as to maintain the higher ideas of beauty. This orderly outline of objects is a principle which has been carried out in the best constructive works of all ages; not only in architectural buildings, but in small household objects. A Greek artist, for instance, never allowed the carving on the side of his vase to project beyond the general form of the vase, because the carving would then have taken away from that orderly, graceful outline which was the first essential to its beauty. The large building and the small vase are alike in this particular, that they are both to be seen on all sides, and it would seem to be a law in art, that any object which is intended to be seen from all sides, should from all sides present to our eye a regular, graceful outline.

If we carve a member of the building, as a column, in direct imitation of a natural object, this regularity of outline from different points of view will be lost, and this imitation would seem to be specially objectionable when the object is placed on the top of a building so as to stand out in relief against the sky, because the irregularity allowed to the best periods of architectural art in the world's history, that all imitative works should have a distinct enclosure or frame of their own, but that all creative works should stand by themselves. For this reason all naturally carved figures in Classic architecture are enclosed in panels, and in Gothic architecture in niches; the niche is the house to the figure, and the figure the tenant to the niche, and they are necessary to each other. All the members of the building, on the contrary, which were never rendered directly imitable, could well stand alone; they do stand alone, being so strongly marked in the ruins of a Greek temple or in a mound of isolated columns remaining after the shell of the edifice has broken down, appearing, though sadly in want of the work they were created to do, quite capable of maintaining their own ground, and fighting their own battle with the stormy elements around.

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

There can be no doubt that the reason why geometrical figures are not the close imitation of nature for a reality, is the more the geometrical-formed column, and the geometrical-drawn pattern on the wall, lose their rigidity, and become graceful and flowing, like nature herself, always maintaining that rigidity and regularity of outline essential to pure creative art, the object remains more as a caricature of nature wrought by the hand of man, than as an intelligent copy of nature rendered through the mind of man.

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

In order to be convinced of the truth, that we sometimes mistake the close imitation of nature for reality, we only have to enter our well-known London exhibition of waxwork, where I believe not a day passes by that persons are not painfully startled by the life-like appearance of the figures they are beholding. It is true that most of these persons think they are looking at magnificent works of art, and that the painful start occasioned by this life-like appearance is just the proof of it. It only shows how little people in general know what is meant by good and bad art, and how necessary it is for us to try by every means in our power to point out the difference. Without doubt the best reason we can give for such art being wrong, is that it is deceptive art, and nothing which deceives can possibly be right. And this is the reason why the mind is not satisfied by the too close adherence to art to a living object, is that the more nearly the art approaches God's work, the more do we feel in it the want of God's life. The only life an artist can throw into his figure is the life of his own mind, and the more he does that the less directly imitative of nature will his art become.

The close or servile imitation of nature is also the lowest degree of that branch of art. I had occasion to quote an observation of Mr. Ruskin, that the more idea an artist threw into his picture, the less he considered the form of the object which conveyed the idea; but Mr. Ruskin goes further than this, and shows that the too correct drawing of the object takes away color and life from his work. The two things are not so particular about his perspective and his light and shade, and draws the object in a creative manner, so that we see the creative spirit has a great deal in common with the creative manipulation. We may therefore stand by themselves. For this reason all naturally carved figures in Classic architecture are enclosed in panels, and in Gothic architecture in niches; the niche is the house to the figure, and the figure the tenant to the niche, and they are necessary to each other. All the members of the building, on the contrary, which were never rendered directly imitable, could well stand alone; they do stand alone, being so strongly marked in the ruins of a Greek temple or in a mound of isolated columns remaining after the shell of the edifice has broken down, appearing, though sadly in want of the work they were created to do, quite capable of maintaining their own ground, and fighting their own battle with the stormy elements around.

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say that, as imitative art ascends, it becomes more like the creative; and we saw before that as creative art ascended it became more like the imitative. These arts then are as two low extremes, which, in ascending, partially combine, but which, according to the very nature of things, never wholly combine. It is the true painting to be imitative, not geometric, in a success of perfection, and it is its unwise confusion which tends, in decorative art, to ugliness; and in painted ornamental art to that which is much worse, deception.

Let us consider what is meant by their "unwise confusion." I have already observed, when referring to decorative art, how any irrelevant detail and absurdity can be made to appear in ugliness, as in a naturally sculptured figure forming part of the general outline of a building. The naturally sculptured figure is essentially imitative art, and the building is essentially creative art, and yet they are made to form part and parcel of one thing, so that I think the two arts are thus unwisely combined.

They were to be wisely combined if the imitative were kept in its natural frame, and the creative allowed to maintain its regular and graceful outline. Happily, however, it is the rule to find this principle maintained in our buildings; but it is unhappily common to find it neglected in our articles of furniture, and still more so in our small art-objects.

This is the cause of the confusion of decorative and imitative art in decoration. The result is ugliness to the eye, causing dissatisfaction to the mind. In painted ornamental art, as I have said, the case becomes much worse, because such confusion actually tends to deceive. We have seen that ornamental art is the beautifying of a surface; and when the art of sculpturing a natural figure and placing it in a niche cut in the surface, or by painting a natural object and placing it in a frame.

As the natural piece of sculpture has already been considered under the head of decorative art, we will now consider what is meant by the confusion of creative and imitative art which is applied to the beautifying of a surface by drawing or painting.

What do we mean by the imitation of an object upon a flat surface? in other words, what do we mean by a picture? You may think that this is reducing our subject to rather an absurd degree of simplicity, for you may very naturally imagine that every child knows, in its picture-painting age, what a picture is. However, it is necessary to our argument to have the picture briefly defined.

I have heard it said that we represent nature in a picture as if we were holding up a sheet of transparent glass before our eyes, and copying the objects upon that glass as we see them. This is quite true, but it is one thing to observe the phenomena of that sheet of glass,—it must not be too large; we should be able to see the whole picture before us without moving the body, or even the head; and there is only one point of view from which we should take in the whole with ease. We must therefore be able to see the edge of the glass, or, in other words, the line by which the image is bounded. This line is not destroyed by the picture, and placed it upon a wall, this boundary line is generally made to separate it still more from surrounding objects by a margin of some breadth. This boundary line then is one essential characteristic of a picture. (It may here be observed that there are two kinds of boundary lines to a picture, one which marks it off suddenly from surrounding space, and that which marks it off gradually, as in what are called "vignette pictures.") Another characteristic of the picture is, that, on account of its perspective, and its light and shade, every needle's point of the surface painted upon becomes lost to the eye, with regard to the picture; but another truth is that the surface is not considered. This boundary line then, and this losing of the surface, are sufficient guides for our determining what is meant by an ordinary picture, or a piece of imitative art upon a surface.

The beautifying of a surface in creative art is simply the reverse of this. There is no need for such a boundary line, because the object itself is on the surface; therefore scultured figures might stand alone; and, unlike the picture, every needle's point on the surface of the object is maintained to the eye, and not lost.

It is so easy to roughly imitate a piece of nature upon a flat surface, and to forget the great primary object in making the imitation, that the confusion of creative and imitative art in decoration is common to the theater and the shopfronts. The great stumbling-blocks to art-progression at the present day.

If we imitate any object whatever by attending to some of the essential conditions of imitative art, and neglect others, then we are confusing creative and imitative art. If, for instance, we imitate a vase by putting it into perspective, and directly copy it in light and shade, and then leave it standing on the surface by itself, and neglect to fulfil that other condition of imitative art by surrounding it with some boundary line and by filling in some background, which the glass if held up to nature would show us, then we are confusing creative and imitative art.

An object pretends to be creative art because it stands by itself, and has no boundary line; and it pretends to be imitative art, because it is drawn in perspective, and in light and shade; so that it becomes to the eye a confused art, and I am persuaded, however well the object may be drawn or painted, that the eye can never be really satisfied in beholding it. Besides, as I have observed, such art tends to deceive, because the object drawn in this fashion, if well drawn, will appear to stand out to such a degree from the surface of the wall, as to make us believe that we are looking at a real object, and not at a painting.

It may be said that the beautifying of a letter over a street door, or a large ornament over the door of a house, is not to attract our attention. But the truth is, that the very commonness of the art raises it to one of great importance. I have heard it said, when speaking of its importance,—"Well, but what does it matter? People like the letters which you say are bad; and, at any rate, they can do no harm.

But I am of opinion that people do not like this false art, and that it does do harm. I believe that a very large majority of people at the present day do not really know what they like in matters of art, simply because their minds have not been educated to understand the difference between good art and bad; and surely, if people are the better for good art (which I suppose will be allowed) they must be the worse for bad. We may say (according to the words of a writer before alluded to), "though the wrong may not be grave enough to be indicated by a power so solemn as conscience; still, constant wrong-doing, in however slight a degree, cannot be without a jar of the entire moral nature.

Unfortunately for art, our so-called people in general, together with those artists who pander to their tastes, are the rulers of art at the present day; and if what I have been saying with regard to this painted vase be true, then nine-tenths of the arts as practised around us are wrong.

Then we must condemn all our highly naturalistic wall-papers, and all our highly naturalistic art-papers without number, wherever any artist is attempted beyond the simple picture; nearly the whole French school of ornamentation, and a large portion of the English founded upon the French model; the well-known Arboises of Raphael, because in them we have constant repetitions of the false principle of this painted vase, &c.

I am quite willing to admit that there is a fascinating kind of beauty in such works as these, which would probably in most cases be lost if they were done rigidly true to principle; still the fact remains, that what beauty they do possess is founded on falsity, and we may be sure that the mind can never be truly satisfied in such an art.

But there would seem to be a struggle now beginning in the art-world around us, between a quiet, good, unpretentious beauty, combined with true principle, on the one hand; and a loud, staring, though fascinating beauty, combined with false principle, on the other. It is of course unnatural that truth and beauty should be found if it is painful to the eye, and as poorly fought, aided by the people themselves for whom the fight is carried on, the combination of true principle with perfect beauty must triumph in the end.

Again, as the imitative or round-wall painting is only intended to be seen from one point of view, so the creative or picture on the wall painting may be seen to advantage from any point of view.

* One of the ordinary block-printed vases for paper-hangings, was here referred to as a "vignette," and also one of the ordinary painted iron letters so common over shop fronts; other ornaments of a similar nature were also illustrated.
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL

That which causes this flat painting to be seen from many points is because it is drawn from many points; and it never appears rounded; it is drawn distorted.

Most persons of our day who think at all upon art-matters seem to have an idea that the correct drawing of an object in nature means the drawing in perspective from one point of view, and in light and shade; and think that they live in remarkably clever times because we are so well acquainted with such rules. But there is another point of view and a different manner of using them. It may be said, there are different points of view, and may see an object from many different points of view; so why should he not, if possible, represent nature in his drawing in all these different views at once? He will make a much more complete work of art, than by giving us his view as seen from one point.

But it may be said, "There is always perspective, and light and shade in nature; so to have, correct drawing, we must have these." It is true that we must have this correct drawing if our object be to add beauty to a surface by imitative art, but if it be to beautify the surface itself by creative art, then we must dispense with the one point of view, with perspective, and with light and shade, and draw what I please. I have often wondered why our writers on art have never made use of this word "distorted," when referring to flat painting; indeed, just where the word ought to have been employed, I have found it most carefully avoided. Yet, why should we be afraid of using this word, if it be the true word? There is nothing in its use, and so why should we not paint the way nature distort nature; and this distorting of nature must be a good thing if it prevent nature from being distorted to our eye.

The Japanese are perhaps the greatest creative artists of the present day, because in their creative art they approach as nearly to the point of view that it is the present day. For example: the plane-painter in Japan, referring to the drawing of the Greeks we may quote the words of Mr. Ruskin, and say "It is in harmony with all true rules, and involves thousands too delicate for ear, or eye, or thought to trace;" but let us remember, that however high may be the flight of genius in either creative or imitative art, the two arts must always remain in strict distinction from each other. We have seen, any object whatever must be beautified either in its form or on its surface, and this can only be done by imitative art on the one hand, or by creative art on the other; and just as we may say that literature generally is divided into the historical and the novel, and that, however like a novel the history may be written, or to what extent the novel may be based on historical incidents, the one book remains as a work of fact, the other as a work of fiction; so we may say that art generally is divided into the imitative and the creative, and to whatever degree these may approach each other, the eye should always be able to tell at a glance for which a work is intended, otherwise there is confusion.

I will now show what is meant by light and shade, as opposed to what is sometimes termed light and dark. When we draw any round object in nature by imitating, we must show high lights, half tints, deep shades, and reflected lights; but when we draw a flat object in a creative manner, this light and shade is altogether out of place, and we have as an admirable substitute, what we may call light and dark.

Let us now enumerate the chief points of essential difference between creative and imitative art, as they are rendered by painting on a surface.

1. In imitative art a boundary line is essential. In creative art it is not essential.

2. In imitative art there is perspective, and light and shade, so that every point on the surface is lost to the eye with regard to the surface. In creative art there is no perspective, and no light and shade, so that every point on the surface is maintained to the eye.

A drawing of a Japanese flying stock was here exhibited as an illustration. The head, neck, and back of the animal were in a direct view, the tail about as if looking directly upon it, the nearest wing was raised high up and suddenly folded over the body, the upper part of 2nd wing was close to the body, but not as in the illustration, high up. The bird was drawn raised up above the other; so that the bird was drawn in a perspective manner, but correct as a piece of imitative art, but correct as a piece of creative art. In this case it was drawn with great care, to the objects of ornamenting the flat surface, and while doing this the artist took the opportunity of drawing the most magnificent and beautiful part of the wing, the tail, the head, and the neck. We should have a more complete representation of the animal than any direct imitative drawing of the feathers of the Egyptian flycatcher, from the study of which the Egyptians were so much more faithful, exhibiting, illustrating the same principles. The Egyptian drawing was so rigidly true to perspective, that the beautiful grace of nature was very much lost; but the Greek drawing exhibited a most wondrous combination of those two things.

3. In imitative art the object being copied from one point only, admits of our seeing it only from that point. In creative art, the object being copied from different points admits of our seeing it from several points at once.

4. In imitative art we never distort nature. In creative art we must distort nature.

It is to be regretted that creative art is not more commonly studied among us, indeed, as regards the drawing of life in nature, we have so many excellent artists; and yet, if what I have been advancing be true, it has some striking advantages over imitative art.

There can be no doubt that if we choose to beautify the surface of our walls by imitative art instead of creative, it is quite legitimate to do so; but there is one kind of surface to which I would refer, where the direct imitation of nature never can be legitimate. I mean the surface of glass; and as I make glass painting my occupation and study, I cannot refrain from giving my notions of the principles of that art. If it were possible to produce a picture upon glass, there could be no reason why we should not have window paintings as well as wall paintings, but light will shine through different portions of the picture, and reveal to our senses that we are really looking upon glass, then this losing of the surface painted upon never can take place, and the absurdity of attempting the pictorial style is evident. This same is true of picture-painting on glass, besides another instance of the confusion of creative and imitative art, and how well confusion leads to deception. The lines which separate the different pieces of glass in a window are by the pictorial artist as much as possible hidden to the eye. His endeavour is to deceive us into the idea that we are not looking upon a piece of mosaic or a piece of glass. The pictorial artist, on the contrary, is true to the nature of the material upon which he is working, and, by taking every possible advantage of these necessary lines, makes the subject tell a thousand-fold better than when they are purposely concealed. These remarks will also apply to the right mode of treatment in the mosaic inlay of glass. We have picture painting on glass, a piece of deception which is very likely to succeed.

But the pictorial painter upon glass, or he of the vase, may say that he does not mean to deceive. The answer to this is, that it is nothing what he may mean or may not mean, so long as his art conveys to our minds an idea that he does mean it.

Thus, as a general result of such an argument, comes the most fulsome of statements, "Well, but what is the use of painting upon principles in art? paint as you please, and we must study to please the tastes of our customers." "So we should if we were butchers or bakers, and our customers had peculiar tastes of their own, though even then we might venture to suggest that certain kinds of commodities were more palatable and better for digestion than others, without perhaps giving offence to anyone; and if a baker might do this with impunity in a matter concerning the well-being of the stomach, how much more should an artist in that which has so much to do with the good condition of the mind. And indeed, there is a strange affinity between the last and this, that paint and the mind. There is nothing particularly tempting or tempting in our ordinary diet; it is the extraordinary dishes which take the fancy, and work the harm; so there is nothing particularly fascinating about simple, truthful art, it is the great gaudy things which affect the eye, and hurt the soul. But all sensible people adhere to good, simple food, because they know that that is best for them; and all wise
ARTISTS PRACTISE THAT GOOD TRUTHFUL ART WHICH THEY KNOW IS BEST FITTED FOR THE MINDS OF THOSE WHO ARE TO SEE AND PONDER.

TASTE AND KNOWLEDGE, THEN, GO HAND IN HAND; AND BURKE, IN HIS "ESSAY ON THE SUBLIME AND BEAUTIFUL," HAS FORCIBLY POINTED THIS OUT. HE WRITES,—"IT IS KNOWN THAT THE TASTE (WHETHER IT IS) IS IMPROVED EXACTLY AS WE IMPROVE OUR JUDGMENT, BY EXTENDING OUR KNOWLEDGE, BY A STEADY ATTENTION TO OUR OBJECT, AND BY FREQUENT EXERCISE."

IF TASTE, THEN, DEPEND UPON A KNOWLEDGE OF THE SUBJECT UPON WHICH THE TASTE IS TO BE EXERCISED, AND IF THIS KNOWLEDGE BE SIMILAR IN DIFFERENT INDIVIDUALS, TASTE MUST BE SIMILAR IN DIFFERENT INDIVIDUALS. AND THIS IS A TRUTH TO WHICH ALL OUR GREAT WRITERS UPON ART AND DRAWING WERE ACQUAINTED, THAT ONLY ONE QUALITY OF DRAWING EXHIBITS THE TASTE OF THE DRAWER, AND THAT THERE IS A STANDARD OF PERFECTION, FOR WHICH WE SHOULD ALL STRIVE.

IT MAY BE ASKED WHY IT IS THERE IS SO MUCH BAD TASTE IN ART AT THE PRESENT DAY, NOTWITHSTANDING OUR ADVANCEMENT IN GENERAL EDUCATION AND KNOWLEDGE! BUT IT IS NOT THE WANT OF GENERAL KNOWLEDGE, BUT THE WANT OF THE PARTICULAR ART-KNOWLEDGE WHICH IS AT FAULT; AND WE ALWAYS FIND THAT OUR MEN OF GREATEST TASTE ARE THOSE WHO HAVE DEVOTED MOST STUDY TO DISCOVER THE PRINCIPLES WHICH SHOULD GUIDE THEIR TASTE. THE VULGAR ARGUMENT THEN, THAT WE MAY DO WHAT WE CHOOSE IN MATTERS OF ART, BECAUSE TASTES DIFFER, FAILS TO EXPLAIN THE EXISTENCE OF WHAT IS KNOWN AS "FINE ARTS," WHICH WOULD NOT BE AGAINST THE LAW OF THIS PAPER, BUT IT IS ALREADY EXTENDED BEYOND ITS PROPER LIMITS.

WE HAVE INDEED A GREAT CONCLUSION IN REASURING UPON ANY SUBJECT, THAT IF SIMPLE FACTS ARE LAID BEFORE US AS A BASIS FOR ARGUMENT, AND IF WE DO ARGUE UNBIASED BY PREJUDICE, OR UNINFLUENCED BY ANY OUTWARD CIRCUMSTANCES WE MAY BE SURE THAT WE SHALL ULTIMATELY AGREE AS TO WHAT IS MEANT BY THESE, TO US, MOST IMPORTANT WORDS, "TRUTH IN ART."

Mr. Lewis said that, though he agreed with the greater part of Mr. Lyon's paper, he could not accept one principle laid down in it, viz.: that painting was an essential point in creative art.

Mr. Ridge observed, that it was not had drawing that Mr. Lyon contended for, but drawing suitable to the position for which it was intended. Referring to a Japanese drawing of a stork which Mr. Lyon exhibited, Mr. Ridge allowed it was not strictly true to nature; it however was not intended for a picture, but for a decoration, and as such he considered it excellent. He allowed it was not the kind of drawing with which a work on natural history should be illustrated. The principles advocated in the paper had, in the present day, a great advantage in contending with those of an opposite character, inasmuch as those latter had ceased to produce works like Raphael's Ariasches, and were reduced to such things as shaded letters over shop-fronts. In this matter the great thing was to discriminate whether we had to produce a picture of description, and when the principles laid down on creative art might lead the architect to adopt, was often more useful than decor of a more ornate character; as the architect wanted that which would be most suitable for the position he desired, not that which was the greatest show of skill. Ridge considered the statues of the Metropolis confirmed Mr. Lyon's views, as their appearance was most uncomfortable, and those of bronze were particularly objectionable; he concluded by moving a vote of thanks to Mr. Lyon.

Mr. Gilbert Redgrave thought that Mr. Lyon had, to a certain extent, been misunderstood, for he considered that his remarks only referred to the creative and imitative parts of decorative, and not of pictorial art. With respect to decoration, he considered that any ornament applied to a flat surface which did not include any relief, was wrong. In wall-decoration the employment of forms suggesting relief might perhaps be permitted, but anything of the sort in carpentry or pavement was most disagreeable. He had frequently seen encroachment made upon the sills of doors and windows, the one a group of pyramids. He could not agree with Mr. Lyon as to the art value of the specimens before them, of Egyptian, Greek, and Japanese creative art; he attributed the falseness of their drawing, and the absence of perspective, to the emplement of an angular figure before them, as showing the full front and side view at the same time: an utter impossibility in nature, and therefore no theme either for the artist or the decorator.

Mr. Lyon, in answer to an enquiry, said he thought it was allowable in stained glass to have light and dark, but no light and shade, and no perspective.

The President said that, glad as he had been to listen to the paper, and to the debate which had followed, he had not been able to agree with all that had been advanced. He should be sorry if artists of the present day had to take Egyptian or Japanese drawings as models, and with all due deference he must beg to differ from Mr. Lyon. The beauty of all art, whether creative or imitative, lay in its being as near truth as possible. The man who designs a work of creative art must have the love of truth in his soul, and must have nature always before him, guiding him in the laws of his art. The Assyrian and Japanese drawings which Mr. Lyon had enquired so much, although not true to nature, were false to nature, and therefore he did not think the style worthy of imitation. He remembered seeing some decorative figure drawing of the fourteenth century, upon some armories at Noyon and Bayeux, which, although painted only in flat, was free from the flatness so much characterised the Egyptian and Japanese style; there was no attempt in them to give flat and round drawing at the same time. His (the president's) own opinion was, that all art which tended to distort figures for any purpose whatsoever, was utterly wrong; and he thought that, although much of the distortion might be taken away by cleverness of drawing, as exemplified in the drawings referred to, yet it was always more or less apparent, but although differing with Mr. Lyon, he had derived much pleasure in listening to his erudite paper.

The vote of thanks was carried, and Mr. Lyon replied.

Christian Architecture in the East.—In our report of the discussion on the above paper, which appeared, at page 50 of the last number of this Journal, an error appears which we regret. Mr. Edis, the President, was made to say, that "He did not think that churches ought to be built, in the nineteenth century, with a grand nave, long aisles, and long transept, of which the windows all exit only by Edis was that he thought in many respects, particularly as regards the plan, the Byzantine church might be taken as a type for many of our modern ecclesiastical structures, for which the grand nave and aisles were so eminently adapted.

SIR DAVID BREWSTER ON THE PATENT LAWS.

At the commencement of the present session of the Royal Society of Edinburgh, the President, Sir David Brewster, delivered the opening address, in which he took occasion to review the working of our Patent Laws. The great experience and authority of the learned and eloquent author will render his views upon the subject especially interesting to our readers. Sir David Brewster said:—

Among the various functions which our scientific institutions are expected to discharge, not the least important is to foster the labours and protect the interests of discoverers and inventors,—of those who create new forms of matter and new processes of art,—who invent new instruments, and new machinery for controlling and rendering useful the forces of the material world. Among these, the general application of properties of things to be the character, and by whatever means it has been acquired, has ever been held sacred, even in barbarous communities. The hoarded treasure, or the portion of the earth's crust which it may purchase, can be wrested from its owner by the forfeiture of crime or the grasp of conquest. As civilization advances, new arts are developed, and new rights are established. The historian, the philosopher, the antiquary, and the poet,—the pioneers of intellectual life,—strive to instruct and amuse us, and claim in return our sympathy and protection. Hence has arisen the law of copyright, in virtue of which the author of any work, however frivolous in its character, however immoral in its tendency, however subversive of order, and however hostile to religion, acquires a right of property which successive acts of Parliament have enhanced in value, by lengthening its tenure and adding to its security. This just privilege, of which the humblest and the highest in the community avail themselves, is granted gratuitously by the State, and is enjoyed during the long period of forty-eight years, and by the youngest author during the whole of his life.

In the progress of civilisation, wants other than intellectual demand immediate gratification. The genius of invention, in its youngest exercise, is summoned to feed and to clothe us, to continue us from the inner and outer world; to give us the element of life, to strengthen the human arm and aid the falling eye, to shield us from the elements, and to open to the missionary and the merchant the rough pathway of the ocean. In its manhood, it is summoned to more transcendental functions; to supply, for the higher civilisation, the luxuries and elegancies of life; to carry us safely and safely over earth and ocean; to navigate the fields of either; to converse with the world, in accents of lightening, through the air and under the deep; to bring within our reach the most distant star; and to reveal the minutest life which
swarms beneath and around us. With such functions to discharge, and living discharged, them nobody the inventor might have looked for a lucrative patronage from the State, and for a monopoly as free and secure as the copyright of the author.

The right of property in inventions has been acknowledging by almost every community in the old and the new world, and a patent law has been passed to define its character, to fix its limit, and to secure it against infringement. In England, I grieve to say, her inventors are more cruelly taxed than in any other part of the world. Though her prosperity, more than that of any other nation, depends on the encouragement of the industrial arts, yet she levies from the poor inventor—nay, from her best benefactor, the enormous sum of £175 for a patent-right of fourteen years. The Saxon, for the same term, is given for £60, paid by instalments of £4 for each year of its tenure; and in the United States a patent continues seventeen years, and costs only £7 6s. 10d. In Sweden and Norway a patent is given for fifteen years, for the mere expense of advertising the specification. In other countries the diversities in the expense and endowments of her faunus are transferred to the pockets of ignorant officials, and, in this country, accumulated in the coffers of an overflowing exchequer. This and such ungenerous legislation it is not difficult to discover. The average number of patents granted annually in England is 2000, in France 4000, and in the United States 4000; and hence we are entitled to infer that upwards of 2000 patents are annually suppressed in England, and that many valuable inventions and processes in the arts are either not perfected by their authors, or employed in secret, and for ever lost to society.

This is not the occasion to analyse the patent laws of England, and to criticise the principles which are supposed to regulate their enactments. It may be enough to have referred to the miserable result of fourteen years' frivoulses in the Saxon; to the crushing tax of £175 which they levy from him; to the illusory privilege which they give him; to the endless litigation which they lead him; and to the bankruptcy and ruin in which he is so frequently involved. There are, doubtless, many cases in which patent rights have led to fortune, but it is chiefly when the assertion of the true sense of their terms, can be maintained only by ignorant or interested parties. There is no patent that does not contain a proposal to do something that is new, or to make some improvement upon what is old; and there are many examples of apparently useless patents containing the germs of future and valuable inventions. There are many cases, in which the invention is appropriated as an essential element in a future patent, where the new patentee has piratically used it, and dared to complain that he has been prosecuted for infringement. But there is still a still more intelligible reason why no patent can be called useless. In bringing it into the market, workmen are employed, and materials purchased; and if the process, instrument, or machine thus offered to the public has no sale and no useful application, the helpless patentee has given liberal fees to several functionaries of the State, and contributed nobly to the patent fund.

That any patent is frivolous and injurious, in the sense of interfering with the functions of honest traders, is simply untrue. If an invention which has been patented at the cost of £175, and produced nothing in return, is a necessary part of an important invention subsequently patented, it is a positive proof that patents apparently frivolous may be truly valuable. The first invention is, therefore, neither an obstacle to improvements, nor a ground for litigation. It has, on the contrary, led to a greater profit than the second to the inventor, and the whole interchange of these benefits which may suit the public interest, and be beneficial. It is true that the inventor, or when the patent has been confirmed by the decision of a court of law. The injustice of the patent law has been so fully admitted, that various acts of Parliament have been passed in favour of the patentee, aiding slightly to the protection of his right, and reducing to the sum we have mentioned the expense of it. But even so, no addition has been made to the shortness of its tenure, and no increase of security against direct piracy or partial infringement.

Whatever difficulty the statesman may experience in giving security to the rights of inventors, he can have none in giving them the same tenure as copyrights, and conferring them at gratuiously, or at no greater cost than is necessary to cover the expenses of the patent office. Between the national claims of authors and inventors there can be no comparison. Value as you may, and value highly, the treasures of ancient and of modern thought, what are they when weighed against the inventions of art and science, predominating over our household arrangements, animating our lives with the stimuli of wandering and with mechanical life the earth and the ocean? The eloquence of the orator, the lesson of the historian, the lay of the poet, are, as it were, but the fragrance of the plant whose fruit feeds us, and by whose leaves we are healed; or as the auroral tint which gives a temporary glory to a rising or a setting sun. But great to the favoured genius of copyright its highest claims, and appreciate loyally its most fascinating stores, their value is shared, and largely shared, with that of the type, the paper, and the press, by which these stores have been multiplied and preserved. The relative value of books and inventions may be presented under another phase. Withdraw from circulation the secular productions of a press that are hoarded in all the libraries of the world, and society will hardly suffer from the change. Withdraw the gifts with which art and science have enriched us—the substantial realities through which we live, and move, and enjoy our being—and society collapses into barbarism.

* Switzerland, China, and Japan have no patent law.
have wholly overlooked the international interests that are at stake. If we have no patent law, we deprive every foreigner of his existing right to a British patent. Foreign governments may therefore adopt a policy of retaliation, and refuse to our countrymen the patent rights which they now so freely enjoy; or, what is more probable, they may hold us to a contravention of moral agreements with their ingenious artisans, and thus obtain the first-fruits of their skill. Inventors will follow their inventions, and in the exodus to foreign countries—to the United States, especially, with its cheap and judicious patent laws—we shall lose, more rapidly than we have yet done, the most ingenious of our inventors, and the most useful ones.

A policy like this, so Boeotian in its character, and so injurious in its results, is as politically unsafe as it is socially unsafe, and personally unjust. Rights that have been firmly established and long enjoyed are not readily abandoned. Illiberal and oppressive as the patent laws are, they are still the Magna Charta of the commonwealth of inventors, and in an age tending to democracy they will not be surrendered without a struggle. Rights hitherto unquestioned, and not more sacred, may be exposed to the same scrutiny, and social interests endangered which all classes have been accustomed to respect and defend.

If these views of patent rights be just, and if, as moveable property is regarded as an immunity, there can be no just reason why they should not be granted equally cheap, given to every applicant, and enjoyed during at least the life of the patentee. When a philosopher or an artist offers an invention to the State, and receives an exclusive privilege in exchange, we might expect some equality between the gift and its reward. In particular, we might ask whether the instrument of his time, and in many cases exhausted his means. When a suppliant at the Patent Office, a heavy payment is demanded, and he purchases a privilege which may ruin him. The theory of such a tax it would be difficult to discover. Its avowed object is to diminish the number of patents, for the benefit of the inventors; but the object which it actually accomplishes is to paralyse inventions; to cause valuable processes to be wrought in secret, and in many cases to be lost; to give fees to clerks and officers of state, and to create a fund, the purpose of which has not yet been revealed. A tax sufficient to defray the expenses of a patent is not the justly exacted, but to demand a twenty-fold that amount is a freak of finance, alien both to reason and justice. Will it be believed in an enlightened age, that the sum paid by inventors to the State during nine years and a half, from October 1852 to December 1861, was $777,777, which, at the same rate, will be $1,093,794 at the end of the present year? The sum of $77,777 received in 1852 has been expended, viz., $396,000 in fees to law officers and their clerks, who do nothing for the inventor, and $406,000 for the expenses of the Patent Office. After all this expenditure, the enormous sum of nearly a quarter of a million of money, wrenched from the inventive genius of England, Germans, Slavs, and Hungarians, while our statesmen and stateswomen are left to starve, and the interests of science and art consigned to the mendicancy of our scientific institutions.

In discussing the policy of untaxing, extending, and securing patent rights, we may view them in relation to the doctrine of free trade, now developing itself in the legislation of every civilized community. In the present state of the law, patent rights may be said to be imparted and exported as freely as the instruments and machines in which they are embodied; but in so far as they are more taxed in one country than another, the trade in their products and in their privileges cannot be considered free. A discovery in science, and a process or invention in art, are given to mankind by the families to which they are made, and whatever be their character. To fetter their development in one country while they are fostered in another, is an act of international injustice, which free trade disclaims. To tax them anywhere, under any circumstances, and under any pretence, is a blot upon political wisdom, an act of cruelty to genius, and an injustice to mankind. In an age which taxes the means of production, it is peculiarly degrading to be taxed for the privilege of producing. In tracing the rise and progress of those great inventions and discoveries which have added to our physical enjoyments and consolidated our power over the material world, we cannot fail to recognize the grand object which, in the arrangements of Providence, they are meant to accomplish. Whether man is fitted to understand he is destined to enjoy. We have yet much to learn of the aereal universe of which we form a part; of the system of planets to which our own belongs; of the physical history and construction of our terrestrial home; of the organic and inorganic substances which compose it; of the precious materials stored up for civilization; and of those noble forms of life and beauty which everywhere appeal to the affections and intelligence of man.

But while we have thus much to learn, we have also much to do, and whatever we have power to do must eventually be done. The great inventions which, in living memories, have so mysteriously altered the social condition of our race, measure to us, however feebly, what art and science have still to accomplish. Our gigantic steam vessels, our telegraphs, aerial and submarine—our railways—our lighthouses, are all in their infancy. We have yet to pass through the sea with a swifter compass, a sharper prow, and a stronger impulse. We have yet to speak more articulately through the air and beneath the ocean. We have yet to guard our coasts with brighter beacon and safer lifeboats; and our railways have yet to convey us more swiftly and safely to our home. But, what is more important still, we have yet to discover and combat those subtle poisons which are everywhere assailing the seat of life, and hurrying thousands of their victims to the grave.

In the completion of these great inventions and discoveries, we shall, as it were, learn, that art and science are the means by which the blessings of religion and civilization are to be sent to the distant isles of the sea,—the several families of the earth united in one, and the reign of peace and righteousness established on the earth. But while art and science are thus adding to our social blessings, let us be so much the more zealous in guarding the precious instruments with which these blessings have been imparted to us. In our day have been basely purchased and successfully employed in forging the weapons of violence and destruction. Nor is this a retrograde step in civilization. By increasing the dangers, we diminish the chances of war. In perfecting the machinery of Death, we eventually add security to Life. War may become so disastrous in its consequences, so indiscernible in its laughter, and so appalling in its carnage, that it will cease to be the arena of the heroic virtues; and this bloody scourge of humanity—the master crime of nations—will be crushed by the geniuses of art, and perish by the weapons itself has used.

PETROLEUM AS A STEAM FUEL.

The following exhibits the results of a series of experiments upon the employment of petroleum as a fuel under steam boilers. The experiments were conducted by Mr. Julius W. Adams, C.E., of New York, at the request of the Petroleum Light Company of that city, and are embodied in a report to the directors—

Mr. Adams states:

The difficulty hitherto has been in attempting to burn the crude petroleum, that the imperfect combustion alone attributable to the means in use has resulted in great waste of the material, as shown by the dense smoke which invariably accompanied all attempts to burn it in a confined space. This, and the difficulty of regulating the feed, have hitherto prevented a successful application of this material as a fuel in the generation of steam in boilers. I am well aware that it has occasionally been accomplished on a small scale, but no experiments that I have knowledge of have exhibited anything like the requisite command of the material in feeding the fire, or certainty in its use as a fuel. This remark is made in full knowledge of what has been accomplished in this direction by Messrs. Burton and Shaw, as well as by Mr. Richardson in England. This difficulty has, I think, been successfully overcome in the experiments conducted for your company; and the crude petroleum, without other fuel than the chips for kindling the fires, has been burnt daily under a marine boiler, in a course of experiments extending throughout the whole of the summer season, at large and without any perceptible annoyance to the workmen, who might exist between the two; further experiments being needed in order to determine their precise relative dimensions. The experiments thus far have not extended beyond the determination
tion of the fact that petroleum may be used with great facility as a fuel under steam boilers, by a single fireman of ordinary intelligence. Minute analysis has been made of its comparative economy—the results thus far being regarded as merely general; but from the results herewith shown, you will be enabled to determine how far our experiments sustain the claim we have advanced of having successfully applied this material to steam boilers.

The boiler used was an internal flue and return fire-tube boiler, the shell measuring 13 feet and 9 inches in length, by 6 feet in diameter, with a grate-surface of 35 square feet; contents about 1500 gallons of water to the level of 6 inches above the upper line of tubes. There were three flues in the boiler, the centre one on each side; and another two on the outer or 8 inches diameter. The boiler was not set in the method which we recommended, but rested merely on three walls of the dimensions of the furnace walls. There were five rows of 2½-inch fire-tubes, being seventy-five tubes in all; the back connection being 15 inches by 3 ft. 5 in., and the smoke-stack 30 inches in diameter. The boiler was unclad.

The fire bars were removed, and in their place a coil of 2-inch wrought-iron pipe was inserted, the total length of pipe in the coil being 23 feet; at the back, directly across the furnace, a wrought-iron tube or retort, 5 inches in diameter, and closed at both ends, was placed, with a length of pipe of 3 inches diameter immediately in front of it. Into this latter tube, which indicates the retort) one end of the coil is inserted, and the other end, passing out of the furnace door, communicates with the reservoir of oil, being in this case the cask in which it was brought to market. The flow of oil is regulated by a stop-cock, placed on the door. Six inches under the retort, the pipe lie ten 1-inch wrought-iron tubes, closed at one end, the other end inserted into the retort; these tubes lie parallel to each other, and are 2 ft. 3 in. in length, and into each of them is tapped nine cast-iron burners, with one-sixteenth inch opening, making in all ninety burners. An inch above the plate of the coil, a wrought-iron pipe proceeds direct from the short tube in front of the retort into which the coil is inserted, to the furnace door, and thence to the steam space of a small auxiliary boiler; a branch, with proper valves, connects this pipe with the steam space of the main boiler—the flow of steam being also regulated by a stop-cock, placed in the vicinity of the furnace door, near the oil cock.

The water in the boiler being cold (sixty degrees), at fifteen minutes past two p.m., some billets of pine-wood and shavings, weighing about twelve pounds, being placed upon the coil, near the furnace door, were lighted, and the door partially closed; after fifteen minutes more, a handsome flow of steam was opened, which permitted a flow of oil from the reservoir through the coil; simultaneous with which, or a little later, the steam cock was opened, which conveyed steam of about twenty pounds pressure from the auxiliary boiler, through the heated steam pipe, above the coil, to the retort; where, commencing with the heat from the coil, it passed into the straight pipes, under the coil, and is fired at the burners. The flame was vivid and intense, regulated in its force by the relative flow of oil and steam, and was entirely under the control of the fireman, who, at his pleasure, could reduce the flame to the flicker of an expiring lamp, or extend it, by a single movement, to a volume filling the large flues and furnace with its flame. No smoke or unpleasant smell was perceptible, and the combustion was complete and entirely manageable. Steam, at atmospheric pressure, was raised in the boiler in twenty-nine minutes from the time of admission of oil into the tubes, and the experiments taken in this experiment of the amount of water evaporated; the apparatus not being considered as properly proportioned to exhibit the economical value of the fuel; and the experiment terminated in about one hour by closing the oil cock, and the fire was out.

The analysis of this experiment may be shown as follows. The weight of oil which, consumed under the boiler, raised a given quantity of water from a temperature of 60° to the boiling point, it is requisite, for a comparison with the known effects of anthracite coal, to show the proportionate amount of oil which would be necessary to convert this same bulk of water into steam at the atmospheric pressure, or the weight of water which a pound of this fuel will convert into steam.

According to Tredgold, the quantity of fuel which will convert a cubic foot of water, of a given temperature, into steam, at the pressure of the atmosphere, is obtained by multiplying the quantity of fuel which will heat a cubic foot of water one degree, by the sum of the latent heat of steam, and the difference between 212° and the given temperature of the water. In this case, 212°—60°=152°. The latent heat of steam, according to Dr. Ure, is 977°, which, added to 152°=1129°, which, multiplied by the quantity of fuel which will heat a cubic foot of water one degree, will give the weight of fuel requisite to convert a cubic foot of water from the temperature of 60° into steam. This product multiplied by the number of cubic feet of water to be converted into steam, will give the total amount of fuel required in this case.

Making the proper allowance for the pine wood in lighting the fires, the weight of oil consumed in the experiment was 80 pounds; the contents of the boiler was 200 cubic feet, at a temperature of 60°, which was heated by this weight of oil to the boiling point=212°; thus the weight of oil which heated 200 cubic feet one degree was 0.39 pounds; and the weight of oil which was requisite to heat one cubic foot of water one degree was 0.019 pounds. This multiplied by 1129°=219, and this by the 200 cubic feet of water in the boiler gives 455 lb., as the weight of oil which would convert the contents of the boiler into steam at the atmospheric pressure—or 200 x 1129=225800 lb., 455 as the weight of oil at a temperature of 60°, which will be converted into steam by one pound of oil. From Isherwood's valuable experiment on marine boilers,—we find this same type of boiler in use on board of the U.S. steamers,—and from the mean of the experiments conducted on these, we have the quantity of water evaporated from a temperature of 100° with steam at the pressure of the atmosphere by one pound of anthracite coal, to be 8.5 pounds. To compare this with the evaporation made from a lower temperature of water by means of the oil, this weight must be reduced in the following ratio, established by Isherwood; 968°+112°=1079, 968°+112°=1284 =0.964, which multiplied by 8.5 gives 11.8 as the weight of water at 60°, converted into steam of atmospheric pressure by one pound of anthracite coal.

Comparing this result with that above shown for the product of the combustion of oil, we find the evaporating power of the two fuels to be in favour of the oil, in the ratio of 29.33 to 8.16, or 3.6, weight for weight; the coal and the oil occupying about in comparison with coal; but the advantages of the oil as a fuel for marine engines may be briefly summed up as follows:

Rapidity with which steam may be raised; reduced dimensions of boiler and furnace below that required for coal; the continuous firing effected by feeding the fuel through a pipe into the furnace, thereby preventing the great loss of heat in the furnace every time a fresh supply of coal is thrown on, and the rush of cold air upon the opening of the furnace doors; the freedom from smoke, cinder, ash, or refuse of any kind, which in coal reaches from seven to over sixteen per cent, of the whole amount; in the ability to command a forced fire almost instantly, without a forced draught, which under some circumstances as sea, is of vital importance; in dispensing with the numerous class of coal-heavers, stokers, &c., and all the inconvenience of raising cinders and ash from the furnace rooms; and, finally, the diminished space occupied in the storage of the fuel.

THE NOTTINGHAM SUBWAYS.

Mr. M. O. Tarbetton, C.E., Corporation Surveyor of Nottingham, remarking upon the discussion on Mr. Burnell's paper on the Gas Supply of Paris, endorses the remarks made by Mr. Godwin in reference to the question of laying gas mains in subways; and goes on to state—
"The subways of Nottingham having been alluded to, I will give some information as to their construction, extent, and use; and as the information of this borough has for some time given considerable attention to the subject, their experience may have some little value.

The first subways formed were in Victoria-street and Queen-street, and have an aggregate length of about 550 feet. These new streets were made in the centre of the town, and being the first of a series of extensive town improvements, the corporation were desirous of introducing the best means of preventing the constant breaking up of the surfaces of the public streets for drainage, gas, water, and other services. The subway is 10 feet wide and 7 feet high, and was completed three years ago, and therein were laid the sewers and branch drains, and the gas and water mains are laid therein. The subway is well ventilated, and escape of gas or water has to my knowledge taken place, though the interior has been constantly visited and worked in by the men employed by the corporation and gas and water companies for branch drains and service-pipes. I have never observed a safety-lamp used, or heard of its necessity; and I have seen gas-service connections made with an open light, even with a gas-light obtained direct from the main, immediately contiguous to the branch in course of being attached. Hitherto the workmen alluded to have had at all times free access to the subway.

The second subway was made under Lister-gate, the greatest thoroughfare in Nottingham, and had been widened and improved at an enormous cost to meet the increasing traffic. This subway is somewhat similar to the first, but with improved details as to ventilation, access, and internal convenience; and therein the main sewer of that part of the town is built, with service connection for the houses. This subway is 50 feet long. For some reason the gas and water companies have declined to use it, and have, instead, deliberately ripped up the street with four trenches for two lines (each) of gas and water mains. The corporation are highly annoyed, but notwithstanding, have decided to construct a similar subway under a third street improvement, now in progress.

The advantage of subways (if safe for gas-pipes) is universally admitted, and their most earnest opponents have failed to show any case against them for water, telegraph, and similar purposes (see Minutes of the Select Committees, June 1864); but in respect of gas-mains, there undoubtedly is possible danger (as in every place to which gas is conduct), unless sufficient means of ventilation are provided, and the best modes employed in making and continuing the joints of mains and service-pipes.

I entirely believe in the statement of Mr. Hawkesley, that in a well-managed company the escape from the main is very slight indeed (as shown by the chief gas-works of this country), but sometimes it is difficult to understand that in a well-regulated subway, escape from the mains, to become dangerous, need not take place at all, for the following reasons:—1stly. That they are not subjected to the perpetual vibration caused by street traffic (in a subway there is no vibration, that what obstruction there is is caused by excavations around and under them for services and drainage operations. 3rdly. That they are under regular inspection, and the joints are recut when necessary, or bitumenized or varnished from time to time. 4thly. That oxidation would be less rapid. Furthermore, if an insidious escape of gas happened, an ordinary ventilation would prevent serious consequences.

The wrought-iron services are the greatest promoters of leakage; and during a daily experience of underground works for the last eleven years, I have scarcely ever found a perfect service-pipe which was not new, or nearly so. The line of the pavement could be lifted to destroy the pipe, and the traffic loosens the joints. Now, this may be prevented by lead services; but in a subway the destructive influences mentioned would not operate to anything like the same extent with wrought-iron, and renewal would be readily accomplished.

It has been stated that under the present system escaped gas is absorbed by the water, and that soil forms the base isolation on which to lay the pipes. If this be the opinion of gas companies, the subway plan offers no impediment, as on the side of the subway intended for gas mains the same may be imbedded to any required extent; in fact, this is already the case in Covent Garden and other large areas. The practice of making the excavation has been advanced, but if gas companies prove all their pipes are wrought iron, the expense to be incurred in gas mains will altogether be insensible. It is true, if a large pipe be accidentally broken, the same damage might arise as if the casualty occurred in a street or any other place; but if large operations were in progress in the subway, corresponding precautions would (and could most easily be taken to prevent) such cases. It is only reasonable to expect that in a large system of subways the control and management thereof would be in the hands of a single and responsible authority.

It is the interest and duty of corporations and other bodies having the charge of the highways and streets of large towns, to prevent as much as possible their constant ravishment; and if the subways now proposed will effect this object without detriments to the companies, they ought to be compelled by the Legislature to adopt them; and I think it rather exhibits a want of fairness and public spirit for the gas and water companies considered individually (the latter company without a shadow of profit without giving them the trials which the Metropolitan Board and the Nottingham Corporation have so generously and earnestly offered. It should be understood that the so-called subways in Paris are simply sewers above the water-level, in which the gas and water mains are fixed, and not subways proper, as those in England.

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**IRON ENGINE FITS FOR RAILWAYS.**

(With an Engraving.)

This application of iron manufacture is certainly a step in the right direction. It is needless to remark upon the numerous improvements in the manufacture of iron, and the still more numerous uses to which it has become applicable since the Country Board of Trade (as far as I am aware) was formed in 1845. The application of iron to railway construction is one of those instances in which the profession know well also that there is still a rapid yet steady increase in the use of this metal. Even where timber, stone and brick were considered indispensable, from their peculiar natures, for purposes to which they were applied, iron has by improved processes been so wrought and shaped as to enable it to supersede them. We live in an age of iron, and welcome any new application of that valuable material, when we find efficiency and economy are the results.

For the invention under notice the public are indebted to Mr. Henry James Rouse, Civil Engineer, of Abingdon-street, Westminster, formerly Engineer of the Egyptian Railways. Mr. Rouse's patent promises a safe and durable engine pit, self-sustaining as a girder spanning the entire length, yet light in weight, sufficiently portable, and easily constructed. When fixed, it is amply rigid to sustain the weight of the heaviest rolling stock running over it at high speeds; and while its use obviates the difficulties that sometimes industriously occur in such situations when formed of masonry, due to bad foundations or bedsetting mortar—its price does not exceed that of a masonry pit. We cannot do better than give Mr. Rouse's own description, as contained in his specification, remarking perhaps beforehand, that though the check rails and joints are specified in the specification may invariably be dispensed with in practice when unnecessary.

This invention consists in the construction and employment of "engine pits" or "pits" of metal, by preference wrought-iron, the form proposed being that of a rectangular or square-sided box or pan let into the ground, and carrying the rails upon its upper rim; and in certain cases there may be, in addition to the ordinary main rails, check or guard rails, extending the whole length of the pits, and placed on the inner side of the main rails, and curved or elbowed at the ends, in a similar way to the check rails in "crossings" at stations. The check rails are for the purpose of preventing engine or other wheels from leaving the line at or on the pit, or preserved.

The following is the mode in which the metal engine pits or metal pits are constructed:—They are, by preference, made of wrought-iron, riveted together with angle irons and tee irons, having flanges on their top rims, for the purpose of carrying the rails and meeting the edges of the pits. The two cross-bar ends are either of plain boiler plate or bar iron, connected to the sides and ends of the pits by angle iron or tee iron, or they are to be of chequered or stamped plate, the chequered or uneven surface being underworld, so as to secure a good hold in the ground; or the flanges are of an entire rolled section, to be attached at once to the cross-bar ends of the pit. The bottom plate of the pit is of rough flated, chequered, or other stamped or rolled plate, for the purpose of giving foothold for the workmen who may be engaged in attending to the engines or other rolling stock over
ENGINE PITS FOR RAILWAYS.

H. J. ROUSE, C.E.
the pits. The transverse and longitudinal ribs of tee iron or angle iron forming the framing or stiffening of the pits are placed on the outer side of the pits, leaving a clear uninterrupted surface inside, and forming a good hold in the ground surrounding them outside. Girder and stiffening pieces are used also where it is found necessary, for the purpose of ensuring the rigidity of the whole system of the metal pits. The form of the metal pits may vary, not being limited to the space that may be allotted to them, or other circumstances; and one or both ends may be made sloping, in the form of inclined planes, with transverse pieces of angle, tee, or other iron, to give foothold to the workmen in descending or ascending; or each of the portions may be either held by the rails or otherwise, fastened to the sloping end or ends; or the means of access to the pits may be by portable iron or other ladders or gangways, in which case the ends of the pits may be vertical.

The metal pits may be provided with a box or locker for tools and a place to keep a lamp, such box or locker being attached to the inside of the pits in some convenient place. As regards dimensions, the metal pits are made for railways of any gauge, and their length may vary from a length only sufficient for a portion of, or for a single engine, tender, carriage, or waggon, to a length capable of taking any number of the same combined.

The vertical parts of the iron used in the manufacture of wrought-iron pits are either of the usual kind of rolled or stamped form, or of specially rolled or stamped iron, to suit the form of the pits in as near their entire section as possible. The main rails and check rails, whether of iron or steel, or any combination of metals bearing upon the upper rim of the pits, are either the usual double-bent or single-bent, or a single bent rail of a regularogon, or polygonal, so as to present a uniform support under the curved rails, and the tilting of the outer rail may be effected either by padding or by special chairs, or rails for the purpose. In all the situations where the ordinary engine pits may now be placed, and also in situations where they cannot be used without additional cost and delay, as in embankments and where the heaviest express trains may run over them at high speeds, the metal engine pits are applicable from their self-supporting form and materials, and the latter where a double flat rail and chair is employed.

PARIS UNIVERSAL EXHIBITION, 1867.

Memorandum on the arrangements for the Machinery Gallery of the Paris Exhibition.

By Captain Festing, R.E.

I.—By the General Regulations for the Universal Exhibition, approved by Imperial Decree of the 12th July, 1865, instruments and processes of the common arts are placed in Group VI., which is divided into 30 classes. A gallery 116 feet wide, and 82 feet high, is to be provided in the building for this group. In breadth this gallery is to be subdivided into a central block 76½ feet wide, and two side passages each 16 feet wide, leaving a space of little over three feet at each side for counters and glass cases, placed against the partition walls. In the middle of this central block and running throughout the machine gallery, there is to be a platform 13 feet wide, supported on columns about 14½ feet high. From this platform visitors will be able to see at a glance the machines exhibited. The columns of the platform will also carry two parallel main shafts for transmitting motions to the working parts and under the platform proper are workshops for skilled mechanics, whose work is to be exhibited as examples of the processes of the common arts. In the words of the supplementary instructions issued by the Imperial Commission relative to the arrangement of this group—

"It is not enough, in fact, to show to the visitors of an Exhibition the mechanical powers characterised by power and speed. In juxtaposition with it must be placed the work of man, showing perfection of taste, manual dexterity, and intelligent precision. In adopting this scheme the Imperial Commission believe that they will remedy an evil denounced by the Commission, and at the same time add a perfectly new attraction to the Exhibition of 1867. By this means the Commission hope to suggest comparisons both useful and productive, to bring to light the share of the workmen in the productions of industry, and at the moment when machinery seems on the eve of absorbing every manufac-
ture, to show that for certain works the hand of man can defy all mechanical competition. A special Class of Group X. (Class 95) comprises the machines and implements carried on by hand labour, and particularly those liable to skilled workmen. But some of the Classes of Group VI. are also open not only to the apparatus enumerated in the system of classification appended to the General Regulations (Appendix A.), but also to the workmen achieving, either with hand tools, regular or first-class, or by the aid of these machines produce mechanically. The following may be quoted as examples: in Classes 55 and 56, weaving, rope-making, spinning, embroidery, knitting; and in Class 59, paper-making, bookbinding, &c.

The Exhibition of manual labour will not excite so much interest unless it be placed in juxtaposition with the machinery with which it contends with more or less success, according to the particular industry. The workmen who are to use manual labour will find under the platform a view of the collection of machines, but sufficiently near to them to render comparisons easy. The portions of this covered ground space thus converted into workshops will be flanked on each side by a passage 5 feet wide, which will allow visitors to approach and observe in detail the performance of the workmen.

"In order to give greater prominence to the collection of objects comprised in a Class, it is desirable that the public circulating in the lateral passages of 5 metres, which extend along the whole length of the gallery, should be able to see the central block displayed as a whole, without being obliged to make their way into it. To effect this object, the Committees should as much as possible place the machines on open platforms, and prevent the erection of any barrier which may impede the development of this form. If necessary, steps with proper foundations raising one above the other would produce this amphitheatrical effect."

"On the other side of the 10½ foot passage laid out on each side of the central block, tables and glass cases will be placed at the wall for the reception of a multitude of objects, machines or apparatus of small size, which would be lost amidst the larger engines placed in the central block. Lastly, the partition walls of the great gallery which has just been described will be available for the exhibition of drawings, trophies, and objects which are of no great thickness. This additional space, which it will be expedient to turn to account, will give a desirable depth to the space where the objects are exhibited. Each Committee should make every effort to obtain for their exhibition those little known and attractive processes, each successive stage of which can be followed, showing how the raw material is transformed into the finished product. Under this head may be mentioned the manufacture of paper, completed by the process of printing, paper-making, weaving, &c. It will also be desirable, where in any Class the manual labour can be brought into proximity with the mechanical, to find a place for the workmen under the central platform, provided the general arrangements do not suggest a more suitable spot."

II.—The cost of all foundations, &c., and all erections and fittings necessary for the proper display of the objects in this group, will be paid by the exhibitors. The cost of the machines exhibited will of course be procured principally by steam, but other means will not be excluded. Instead of the supply of the motive power being carried out, as hitherto, by the administration, it has been decided to employ the system of private enterprise, and to distribute the generators of force at various points around the Exhibition Building, instead of concentrating them in one spot."

III.—The whole machinery gallery is to be divided into a number of sections, each of which will have its own system for supply of motive power.

IV.—The Imperial Commission will enter into agreements with contractors for the supply of motive power for the various sections.

V.—The British Executive has arranged to contract for the supply of motive power to the British portion, which consists of two and a half of these sections.

VI.—All prime movers are to be inside the building; accumulators for the supply of water under pressure to hydraulic engines should also be inside, as well as reservoirs for gas, compressed air; &c., for working any part of the machinery, if they are free from danger and inconvenience. The boilers or other generators of prime force are to be outside the building, at the distance of 89 feet from its exterior, or about 127 feet from the centre of the machinery gallery.

VII.—Each section of the building will have its set of boilers. From thence the steam is to be conveyed by pipes to the prime movers in the galleries. The prime movers will not be collected in one large set, but distributed throughout the building, so as to afford the maximum of motives power, from one horse, or half horse power, as supplied by gas engines, to that required for the largest machines. It is requested that those exhibitors who may wish to assign their prime movers to the use of the Exhibition will notify their wishes as soon as possible. They will have to fix on solid foundations and fit them up for work.

VIII.—The only conditions made by the Imperial Commission with regard to the generation of motive force is that those for each section should be in a certain position, on one or both sides of, but close to, a road in the Park which leads to the entrance door of the section. For each section there may be any number of streets of the same or different kinds.

IX.—The boilers, as well as the prime movers will all be considered as objects exhibited, and must be accessible to the public. It will, therefore, be desirable to have as great variety as possible, in order to show the various ways of turning to account the force derived from the combustion of the fuel employed.

X.—All machines which work with their own boilers, and which the exhibitors may wish to show in motion, must be placed in the Park. The Imperial Commission will make special arrangements about such machines.

XI.—Processes which require the use of fire, such as the working of metals, glass making, &c., must be shown in the Park, and the works will be arranged round the boiler houses of each section. The exhibitors will have to construct all the necessary buildings for these works, and to plant, turf, and keep in good order the approaches to their establishment.

XII.—It is suggested by the Imperial Commission that those who wish to exhibit agricultural machines at work which cannot with safety be brought within the building, should club together to erect in the Park, at their common cost, some inexpensive structure for their machines.

XIII.—Those who may wish to exhibit machines for raising water, &c., may in the same way unite to make a pond in the Park. This pond can be supplied from a well in the French portion of the Park.

The Metropolitan Tramway Company and Patent Crescent Rails.—Notwithstanding the want of success of Mr. G. F. Train's project for tramways in the Metropolis, a number of gentlemen have combined together for the purpose of repeating a similar experiment, and have prepared a bill, which will be brought before Parliament upon an early day. Recently Messrs. John Noble and Co., engineers, of Bridge-street, Westminster, exhibited at the Westminster Palace Hotel, a model of the proposed tramway, and described the advantages of the patent crescent rail. The rail is laid below the level, and is such a mere split or chink in the roadway, that the promoters assert that "the most insignificant obstacle experience any shock. The narrow crescent rails are in various places proposed, viz., 1. From the Archway Tavern, Holloway, to the north side of Finsbury-square; 2. From the Seven Sisters-road through the Camden-road to Tottenham-court-road; 3. From Lower Edmonton to the southern end of Kingsland-green; and the 4th from Stratford-grove to High-street.

Sewerage of Perth.—The magistrates of Perth have resolved to adopt a scheme for a general system of drainage for the burgh, keeping in view the practicability of utilising the sewage, and avoiding the pollution of the river Tay. They have engag'd Messrs. Stevenson, of Edinburgh, to report on the subject.

Sanitary and City Improvement of Edinburgh.—A very comprehensive scheme for opening up the truly close districts on the flanks of the ridge down which the High-street and the Canongate extend from the Castle to Holyrood Palace, has been prepared by Mr. Roderick A. F. Coyne, C.E., and submitted to the city authorities. Mr. Coyne's plan includes three great lines of street, the longest and intermediate one extending from the Grassmarket down the (widened) Cowgate, whence it nears more and more to the ridge of High-street as it crosses South Bridge-street, Niddry-street, and St. Mary's-wynd, running on into the Canongate. The third line of streets runs from Grey Friars Church also eastward, passing the College to the Pleasance. The estimated cost of the two first, and most important, of these plans, including Queen's-park approach, is £185,031.
ART IN RELATION TO ARCHITECTURE.

By John P. Seddon, F.R.I.B.A.

This object of this paper is to direct attention to what is the nature and object of Art.

Art may be defined as the skilled labor of man, the object of which is to supersede to what is practical or utilitarian, the pleasurable and the instructive.

In the early days of civilization Art was the simplest, readiest, and most effective means of conveying instruction. At the present time this particular office has been almost superseded by the invention of printing. We know, however, how welcome an aid the pictorial is in the tuition of children, and we have none of us so far outgrown this propensity, chilidish, if you will (and it is to be hoped we never may) as to be willing, if able, to dispense with the object of art, which is still the highest and noblest office of art, and one we owe much, and we hardly know how much, to its influence. Of all the arts, that which has been most serviceable in one of its most valuable offices, that of handing down historical records, architecture has been the most so, and little should we know of many eras in the history of the world but for the fragments of the buildings which modern research has exhumed. Christianity also from its earliest days made use of art, as an able assistant and disseminator of its doctrines. Its Cathedrals were but vast storied books in stone; and their carved portals and painted walls and windows preached to the people sermons, the necessity of which, in those days, when the only books they had access to, we can now hardly appreciate, and it is this superaddition of instruction to the practical purpose, of providing a mere covering for the worshipping multitudes, which forms in those structures the one grand distinguishing characteristic between architecture and mere building.

I am, however, disposed to claim no greatly diminished importance for the other characteristic of art which I have named, that of providing the pleasurable element to the hardy work of man, and I believe it importance to be now-a-days greatly overlooked. This is eminently a scientific age, and science has made, and is making, vast strides, that the comparative progress of art is little noticed or cared for at all—and yet science merely provides the means of life, or curing its ills, while it is art which embellishes it.

Art and Science are the translators, as it were, of the beauty and the construction of God's book of nature. In nature, which of these is the more freely offered to our adoration? We are not to think of man, for his construction, but beauty is showered upon the surface of all her works. We need have no close acquaintance with the hidden machinery of bones, of muscles, and ligaments, to perceive the grace of outline, the glory of colour, or the power of expression which lie on the surface. Inasmuch then as health is prior to disease, and beauty to surgery, which would cure it—so is art the elder sister of science.

It cannot be denied, however, that at the present day there is a wide-spread feeling that art is a luxury, or at any rate anything but a necessity. The world is so absorbed in making money, that it seems to have no time to stop to consider, what alone can make the possession of money desirable. My present object is to show that this should not be so—that it never has been so, until the last three centuries: to prove that those centuries have been none the better or happier for its absence, and that a splendid future lies before us, if we would only accept the doctrine that art should go hand in hand with science, the one assisting the other, adorning, their mutual progress, and yet science merely provides the means of life, or curing its ills, while it is art which embellishes it.

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It cannot be denied, however, that at the present day there is a wide-spread feeling that art is a luxury, or at any rate anything but a necessity. The world is so absorbed in making money, that it seems to have no time to stop to consider, what alone can make the possession of money desirable. My present object is to show that this should not be so—that it never has been so, until the last three centuries: to prove that those centuries have been none the better or happier for its absence, and that a splendid future lies before us, if we would only accept the doctrine that art should go hand in hand with science, the one assisting the other, adorning, their mutual progress, and yet science merely provides the means of life, or curing its ills, while it is art which embellishes it.

I must, firstly, then, show what art has been at different periods in the history of the world.

Its power over the minds of men was early recognized by those who have ruled the religious aspirations of the various nations, and in their hands there has since been no more effective engine, perhaps, than that employed by the Assyrians and Egyptians, and to realize the manner in which it could bind, as in fettlers of iron, the spirit of multitudes, I would ask the reader to accompany me in thought to the ancient city of Thebes, on the banks of the Nile, and to approach the far-famed Temple of Karnac, through its wondrous avenue of sphinxes, more than a mile in length, the river's banks being fringed with the sharp and polished granite, appearing sternly, but calmly, to be gazing into futurity. Between these we pass up to the stupendous Pronaos or Portal of the Temple Courts, flanked on either side by its obelisks, emblems of light, wrought all over, as indeed most every stone, appearing by very multitude of design to realize infinity, with its crown of hierarchy. Beyond, its frowning brows into the spacious outer court with colonnades all round it, and through successive pronavís and courts, until the Temple itself is reached, and we are lost amid the vistas of colossal columns, with spreading lotus capitals, dimly through which may be seen the shrine of the sacred ox or embalmed Ibis, which the dead Egyptians have come to worship. And now in imagination strip the caged beast, or potted mummy, from all this external paraphernalia of architecture and art, and what remains is the bewitching or shrivelled carcass of the god, that myriads of human souls should bow down themselves to it in devout reverence.

Let us pass from this rude, yet indisputably effective style of art, calculated to impress, to bewilder, and to crush into submission the ignorant masses, to the other side of the shores of the Mediterranean, to the Acropolis and city of Athens, and scan there the art which addressed itself to the polished and sceptical Greeks—votaries of the "unknown god," in search ever for something new, and gaze upon their Parthenon, the shrine built to contain the precious chrysa-elephantine statue of Minerva, begirt with fluted columns, forming a grateful shady promenade for those who thronged to do honour to that favourite goddess. There is no mystery, no redundance here, no aid sought by mere magnitude or multiplicity of parts, but instead, by the utmost delicacy and thinness, and innumerable eyes could hardly appreciate, optical irregularities are corrected with scrupulous and scientific care, even its pavement was said for this purpose to have been laid with an exquisitely delicate curvature; the snowy marble have been tinted in order to soften its glare; the aid of sculpture—and such sculpture as the world had never saw before nor since—was invoked to heighten and complete the effect of the architecture, and to speak intelligibly to intelligent men. Take away this casket, with all its lovely setting, from the goddess' statue, which was the gem it was framed to guard, and the crowd of her worshippers would doubt but it had been most woefully thinned.

Now let us follow the stream of time, and proceed to the confines of imperial Rome, and see the wondrous array of arches which traversed the wide Campagna, to bring the tributary waters from the provinces within the walls: to this day the stupendous wrecks of these remain to attest to the magnificence and wealth of the city. Let us enter the vast circumference of the circular arena of the Colosseum, the famous theater of building, in which the fashion of Rome congregated to gloat over the death throes of the victims of the State, and we can read there, in many clumsy expedients to marry the architecture they had stolen from more inventive nations to the science and scale their wealth could command, that their endeavour to keep art as a captive to their capricious one. Still what is there that Rome has left to tell future generations of the sway she once held over the world but the ruins of those her architectural works.

And if we would know something more of the inner life of those days, we may turn to where the ashes and lava from Vesuvius buried us for, and the antiquarian research of the present age has since exposed, the provincial towns of Herculeanum and Pompeii, and there is preserved for us through all those ages even the ordinary decorations and paintings upon the walls of their dwelling-houses, and numerous minute, which historians would have sought in vain; them to have chronicled in their pages, but which are nevertheless of the greatest interest to us, consecrated as they seem to be by their antiquity. Art, however, in the hands of the Romans, sunk at length to such a depth of degradation, that it was no loss to the world when it was all swept away, in company with the empire of which it was a part in the score of invading barbarians, since it slowly but gradually revived again, and under better auspices as Christianity completed its triumph over Paganism.

The period of this revival is one fraught with intense interest in an historical point of view, and from its associations, and yet comparatively little is known of its methods, and whether it was the Revival era, and under better auspices as Christianity completed its triumph over Paganism.

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THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL

own time has good cause to look down upon them, at any rate, when questions of art are under discussion.

Herein lies the architecture and its associated arts of the period appear likely as to afford valuable assistance towards filling up the hiatus in our knowledge of its history and the character and degree of its civilization. For although hitherto but a few remnants had come into our possession of those of a character which led us to believe that art, if not dead, was but as stagnant and undeveloped condition, this has been altered within a very recent period in a most remarkable manner. It would appear to many almost as if the shapeless outlines of the cities of which it was not extinct, to be told that but the other day, not a few isolated structures of this very era had come to light, but that a discovery had been made, in a region but little removed from the heart of modern Alexandria, of which the remains, elegant halls, colossi and other remains, in the details of which may be found the missing links between Classic and Medieval architecture, very different from what had been imagined from what we had previously been acquainted with as the work of the contemporary early Christians, who had Rome passed a hidden and struggling existence in the gloom of the catacombs beneath that city.

Mr. Cyril Graham, who rapidly explored this country in 1857, speak- ing of the enormous city of "Um-el-Gemel," to the South of Borba and the "Beth-gamal of scripture, says, "I wandered quite alone in the old streets of the town, entering one by one the old houses, went up stairs, looked into the rooms, and so a careful view of the whole place; but the perfect were everywhere, every house, every room, that I could have almost fancied, as I was wandering alone in this city of the dead—seeing all perfect, and not hearing a sound—that I had come upon one of those enchanted places described in the Arabic Nights, where the population of a whole city had been petrified for a century."

Venice, which was founded in the 6th century, might fairly be called the battle ground of the styles, and there more simply than in any other city may the history of architecture and its associated arts from this period until the complete establishment of the Medieval Gothic of Western Europe be traced.

The classic art of antiquity was at the time of the foundation of the Queen of the Adriatic, dragging out a languid existence at Rome, under one phase, which was founded upon the type of the Basilica, the old Courts of Justice in the Roman empire, and in Constantinople, and the Eastern Provinces under its Byzantine, under another phase, known as the Byzantine. In Venice these met and contended for the mastery. Here the various nations of the east and west met and built for themselves, under its tolerance and paternal government, according to their own traditions, and without the constraint which we soon see their work united in various proportions in the same buildings. But the northern Teutonic energy was the most vigorous, and before long asserted its supremacy, taking however from each one a characteristic element which it blended with its own, and thence sprang and spread over Europe the Gothic Architecture and Art.

However, the brilliant story of its rise and progress, as written in the stones of Venice, is it not well chronicled in the glowing pages of Mr. Ruskin? I will not therefore follow it further, as my purpose is now to trace the same progress from this point as is may be seen in the noble church of St. Nicholas, Great Yarmouth.

The whole series of the styles of English ecclesiastical architecture are represented in this structure—the first in order being The Norman, this is the English development of the Romanesque, which is the Toscaneo version of the decayed old Roman architecture and spread from Italy along the banks of Rhine and through France and thence into this country, receiving in each a distinct local character. This style is to be seen in the lower stages of the Tower of St. Nicholas, and immediately above the roofs, being a remnant of the original church built by Bishop Herbert, (surnamed Loxinga), to whom this diocese is so greatly indebted for the foundation of the noble Cathedral at Norwich as well. The semicircular arch is the principal feature which distinguishes Norman from the succeeding Gothic styles of the Tower of St. Nicholas's. The details are very simple and plain, and devoid of many of the enrichments which usually are its characteristics; probably from the position of the church upon the sea-coast, its character was half-military, and such simplicity was a necessity enforced by circumstances.

The next period the work of which we find represented in the building is that known by the term "Early English," which is the earliest of the Gothic styles. Without entering into the discussion as to how and whence this style arose; whether it was due to the Crusades, which brought the western to the eastern nations into close if not friendly contact, or to other causes; certain is it that in Gothic architecture, which became indigenous in all the western countries of Europe in the medieval ages are to be found the best elements of both the Romanesque and Byzantine styles, but with the pointed arch as henceforward the ruling form of every opening.

In England alone was the earliest phase of Gothic developed as to form a style of its own, which is termed the Early English, which was developed into the Northern and the Norman arch is the D-shaped openings, used singly or grouped in ovals or tripli, as in the west end of the nave of St. Nicholas's Church, whereas in other countries tracery appears in the windows almost as soon as Gothic architecture may be said to have been established at all.

Another point which should always be borne in mind is that, although for our own convenience we have classified Medieval architecture into distinct styles, these were not abruptly divided, but in point of fact, but passed gently, almost insensibly, the one into the other, and indeed its whole history was but one course of transition or growth.

The architecture of the nave of St. Nicholas's Church may therefore be described as of the period of the transition from Norman to Early English Gothic, and is remarkable for its fine arcades with their admirably varied piers, being circular, octagonal, and shafted in succession.

The greatest feature of St. Nicholas's Church is its unequaled and undiminished aisles, those adjoining the nave are of the more completely advanced Early English or Northern style, between the Early English and Decorated. Their noble west windows show the rudiments of tracery, and doublet in the original side window also. I have prepared a drawing to show what I believe to have been the southern side of the church before it was altered by late additions. The aisle windows still retain the beautiful original internal dressings, it being only the outer framework which was replaced later by perpendicular tracery to their great detriment.

The south porch has been a sumptuous work, of a date somewhat later than that of the aisles. It is of the early Decorated period, with rather curious and unusual tracery, supported by detached Purbeck marble shafts, and an excellent example of the style.

Then we have the chancel and its aisles, and the cases of the transepts and tower piers, of fully developed Decorated work, and the style of Gothic architecture, known as the Perpendicular, which unfortunately do not improve the architectural character of the fabric, although they increase in some degree its antiquarian interest, as a monument embodying in itself the work of all the periods of ecclesiastical architecture.

The interior of this unique and magnificent structure has been restored to its full magnificence, and its just proportions. It is, however, far from being in a condition to convey an idea of the splendour which in olden days it undoubtedly possessed. It is well known that few of our churches, none of our churches St. Nicholas were in unspoiled state of stone and plaster, were all sumptuously enriched with works of high art, carvings and decorated screens, such as Norfolk, beyond any count.
still famed for; and from encaustic flooring to painted and gilded ceilings, the whole glowed with rich and beautiful colouring.

The present generation has made a vast advance beyond the limited appreciation of art which has obtained during the last three centuries, if they can be said to have appreciated art at all.

It is useless to speculate why it was that simultaneously with the Reformation (which we all believe to have been a great boon to the world, as clearing away the mists of superstition that at length had obscured the Christianity of the middle ages) art at the same time fell into so lamentable a state of decay and neglect.

It is the nature of mankind to run into extremes, and the feeling that art had been made the instrument to foster such superstition doubtless helped to lead to a reaction, through which it became altogether ignored and set aside.

Next succeeded a period of stupor, of entire indifference to art, when one could see naught but the merest utilitarianism in such buildings as all.

From this deplorable condition the present generation has awoke. It does at last admit, not only that it has no right to destroy its ancient churches, but that it is a duty incumbent upon it to maintain them, nay even if they can accomplish it, to restore them and have them done over in the manner of their forefathers. All this is well. It is well that this appreciation of art and architecture has commenced with our churches, but I am anxious that it should not stop there.

I wish to plead for the importance of art in our homes, throughout our towns, so that our improved churches should not be so utterly out of harmony with their surroundings as at present, and in the country, so that our villages and cottages should not be such marplots in a fair landscape as they are at present. This was the case formerly. Those who have seen such cities as Rome and Nuremberg will attest that their noble churches are but the best buildings where all are good and of harmonious and picturesque character.

People took then a pride in their houses, and some thought for those outside; their work was solid and substantial, and truly expressed the character and feelings of their builders and inhabitants.

But what does modern building express? Does it express anything? At any rate it is to be hoped it does not express our character. For if so, how could we claim truth to be a part of it, seeing that one material is commonly made to mimic another, as cement to imitate stone, and the whole decoration in general is a system of sham.

For this state of things who is to blame; the art producers, or the public? Really it is a case of the fault on both sides, which act and react upon each other. Primarily it is the fault of the art producers, who have acted the part of unscrupulous parents, by giving stones in answer to the cry of the people for bread; that is to say, giving them nothing that could interest and please them, but instead, only dry scientific architecture, not composed as our own indigenous Gothic was, of fair arches and tracery opening, that everybody could love and understand, but the dreary exhumed dry bones of classic architecture, what they have been pleased to call Italian, and which, however scientific and convenient (though I am prepared to contend it is less so than Gothic), never touches the feelings with the slightest stir.

Then architecture, in modern times, has lost the able assistance of painting and sculpture, by which in olden days it pierced to the hearts of men, our buildings are thus left devoid of colour, and their carving is done by men hardly raised above the rank of masons, and thus cold and cheerless they have no charms for ordinary spectators, since it requires some education of the eye and a considerable intellectual effort to appreciate the merits of proportion, which is all that is aimed at. Our painters are entirely occupied in the production of easel pictures, for which alone they are commissioned, and our sculptors give us little but the annual ghastly array of busts in the dungeon of the Royal Academy, an occasioning galvanic revival of some long-forgotten mythological personage.

Thus the public, accustomed to be treated as if it had neither part nor lot in artistic matters, and finding no pleasure in architecture and in the other arts only in a dilettant manner, has withdrawn its sympathy from them, and makes no demand for a higher description of supply.

Must we then despair of better things? Mr. Ruskin, the eloquent author on these subjects, says he is weary of writing about them, seeing so little result. But I think we may look forward much more hopefully. The progress made by artists of late years is undoubtedly great, and as the demand increases the supply will keep pace.

All should love architecture and art, and not believe there is any difficulty about them; I want all who can enjoy beautiful things in nature to equally well admire them translated into the language of art; and they should believe that architecture, painting, and sculpture, are each and all necessary to complete the picture of the character of the man. Shyly they are imperfect; their strength consists in their unity, which combines the efforts of each, and gives purpose to their power and direction to their aim. Thus architecture embodies but the abstract principles of nature; recreating, by means of her laws of construction and geometry, she gains sublimity by size, by symmetry, and contrast—beauty, by proportion and harmony. She builds up the polished stone of the earth into a music of visible matter, which yet is, and must remain ever but a "frozen music" as it has been called; out of tune with the natural melodies around, which concentrate all kinds of attraction, if she avail not herself of the graces of her sister arts. Apart from these, her means of expression are very limited, and extend not beyond the simplest emotions of the mind, addressing but few of the sympathies of men; with no more power than the lipings of a babe, or the gestures of the dumb. But still, that which she has to say is told from one generation to another, is told so clearly, that men may not but hear; and while she speaks within her circle, the more fragile works of Painting and Sculpture, their voice, whose compass is greater, blends with and becomes one with her own. History lends its associations, and the wild legends there are; and when records have perished and the voice of tradition is still, so long as one stone will stand upon another, time will but add a charm and bedeck the mouldering walls with the golden leaf of the lichen and the moss; till, beautiful, even in death, the last relic is ploughed into dust.

THE ARCHITECTURAL ASSOCIATION.

The ordinary fortnightly meeting of this Association was held on the 16th ultimo, Mr. R. W. Edis, President, in the chair. Mr. Benjamin Lee, Mr. Edward Haschburt, Mr. Charles Dashby, and Mr. Ormond Stanley Brown, were elected members of the Association. The President reported that he had received a letter from Mr. Phipps, of Bristol, the honorary secretary of the Bristol Archaeological Society, bringing before the Association the case of the old demesne within the city of Bristol named Colabore House. It was proposed and carried that the Association should memorialise the Town Council of Bristol, in the hope that they might be induced to save this ancient relic.

Mr. Mathews observed, at one of the earlier meetings of the present session, a question had been raised relative to whether armarial bearings used in building were liable to pay government duty. Mr. Potter, who had communicated with the Government on the subject, had received an answer from the Chancellor of the Exchequer stating armarial bearings used in buildings were not liable to duty.

Mr. Tavener called attention to a letter from Mr. Burgess, addressed to the "Building News," having reference to the Figure Drawing Class, and explained that the statement relative to poor attendance was too incorrect in that it was connected entirely with the school named Colabore House; that during the seven monthly, which it had been hoped would be sufficient to cover the outlay caused by increasing the number of weekly meetings from two to three, he had heard that the expense of running the class was covered within the limits of the Government schools, had detested some gentlemen from becoming members; but he had learned from inquiry, that those who drew from the life in the Government schools, were only admitted after a much longer course of study. The architects did not desire that architects should devote to figure drawing so much of their valuable time as to make them perfect masters of the art, but hoped that many new members, from among the students, especially, would seize this opportunity of acquiring more useful information by attending the class.

PROFESSOR KEMP, F.R.I.B.A., then delivered an address upon DOMESTIC ARCHITECTURE.

The Professor stated that his lecture would be upon the design for an ordinary country house for a gentleman. The plan he proposed to follow in his address was to show practically the way in which he had been accustomed to design the plan
of a country house. There might be some gentlemen present who knew as much as he, but he was aware that there were younger men in the room, and he wished to please them; and in the latter that he addressed himself. He assumed a house, containing rooms of the following dimensions, for the purpose of showing the principle in which it should be planned:—Dining room, 24 feet by 18; drawing room, 24 feet by 18; library, 24 feet by 18; billiard room, 24 feet by 18; gentleman's room, 18 feet by 18; morning room, 18 feet by 18; master's room; 18 feet by 18; servants' hall, 20 feet by 16; scullery, 16 feet by 16; 3 small larders; servants' stairs, 18 feet by 12; butler's pantry, 16 feet by 12; housekeeper's room, 16 feet by 18; a store room; a staircase; a pantry; a kitchen, and a servants' hall; with a large staircase, a large library, and a large drawing room. These are the types of plan, not so much theoretically as for practical purposes. These were what he would call, 1st, the regular type; 2nd, the irregular type; 3rd, the quadrangular type.

The first of these he subdivided again into the square house, the gallery plan and the Cortissoz plan. The second he subdivided into the hall plan, the gallery plan, and the Scotch plan. The third he would show in two different manners, the first with side offices, and the second with rear offices.

Professor Kerr then proceeded to draw in crayon a number of interesting ground plans, illustrating the various styles of which he spoke, pointing out their merits and defects, and giving a number of practical hints as to placing of doors, fire places, &c., which, however, could only be understood by seeing the drawings which the Professor exhibited. Having finished his description of the various styles of ground plans he proceeded to deal with a few questions of interest connected with the subject. He considered it a self-evident proposition that internal convenience should be the first consideration in designing a house. He was not stating a mere truism, which was to enter in at one end and go out at the other. Whatever reverence an architect may have for art, whatever desire to shine, or to produce a grand effect, all must be subsidiary to convenience. Looking at the history of nature, we find, one by one, the elements increase and decrease, until the climax is reached. There is no attempt to make a house on the outside so as to compromise any organic property within. Speaking with reverence we saw that nature never sacrificed the interior to the exterior. The exterior was ever designed with reference to the interior. And in art the same principle ought to be adopted, whether for a warehouse or a church. He could find 500 men who could design a good outside, but he would not like to say how many of them could design a good inside.

He then made some observations on the question of aspect. He would remind them that the sun shone in at six in the morning; on the south side at noon; on the west at six in the evening. Also, he would remind them that the sun rose in the north-west, set in the south-west, came from the north-east keen; from the south-east mild; and therefore the rooms in which the family mostly resided ought to have a south-easterly aspect.

A window to the west will never do for a dining room, because the sun would shine in at such winds, and the usual dinner hour. No; it was therefore the proper aspect for a dining room.

The drawing room must be towards the south-east; it has the benefit of the early morning sun, but the glare is off the windows betimes. The south-east was also best for the dining room, if it could be managed, and in cases where the dining room was also the sitting room, it should have windows to the south-east.

With regard to the question of architectural effect, he pointed out the fact that English gentlemen do not like anything that is obtrusive or conspicuous, or which will provoke remark; they want what is ordinary, not extraordinary; the colloquial sense of the word elegance expressed that which the better class of this and other countries appreciate.

As he observed, there were many men in the present day who seemed to desire to make their buildings as ugly as possible. He did not want too much ornament, but a paucity of decoration or rudeness of execution were not desirable. On the point of style he remarked, that architects were very much divided between the Gothic and the Classic. He would not go into any controversy on the subject, because he considered the controversy a most healthy stimulant. That which is called Italian architecture ought rather to be termed modern European, because it belonged to that reorganization of intellect which took place in the sixteenth century, and spread mainly from Italy to the rest of Europe. He considered there was something pleasant in the competitive rivalry between the Italian and the Elizabethan styles. Neither style was likely to throw aside the other. The Elizabethan tended to add picturesqueness to the Italian; the Italian was fitted to add elegance to the Elizabethan, and the styles offered alternatives. Architects often found the client with a peculiar structure of mind, which led him to prefer whatever was delicate and classical; while another man, perhaps his neighbour or his brother, with different tastes, would have leanings in a different but not in a contrary direction, and would prefer something more picturesque, more 1700, more stimulating. According to the tone of mind which a man possessed, so in a great measure would be his preference. He (Professor Kerr) considered that no architect need have any hesitation in offering a gentleman his choice between the two styles. An architect should feel himself quite at liberty to say to a gentleman consulting him, "You may have either style you please, and that's all."
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

THE MAINTENANCE AND RENEWAL OF PERMANENT WAY.

By R. Price Williams, M. Inst. C.E.

The Author thought it must be confessed, that the condition of the permanent way, so far as regarded its durability, had in no way kept pace with the demands upon it; and that in this respect it compared unfavourably with other branches of railway engineering. Thus, for instance, whilst the weight and speed of locomotive engines had been more than quadrupled in thirty years, the increase in the weight of material resulting from more perfect workmanship and a better description of material was such, that, on the Great Northern Railway, the per centage on the gross traffic receipts for locomotive expenses had even slightly decreased during the last fourteen years, whereas, on another hand, that of maintenance of way had increased more than 200 per cent.; in a similar period.

With a view of showing that the durability of the permanent way, and more especially what was termed the “life of a rail,” had been considerably over-estimated, and further with the object of supplying more reliable means for comparing the cost of maintenance and renewals on different railways, the Author had been engaged for some years in procuring from available sources, tables and diagrams relating to the following lines of railway, arranged according to their mileage:—1. London and North Western; 2. North Eastern; 3. Midland; 4. London and South Western; 5. Great Northern; 6. Lancashire and Yorkshire; 7. South Eastern; 8. London, Brighton, and South Coast; and 9. Manchester, Sheffield, and Lincolnshire.

These tables and diagrams showed, for a period of nineteen years, 1st, the detailed charges of a, maintenance of way; b, staff and other charges; c, works of line; d, stations and station works; and e, renewals of way, all of which were usually comprehended under the head of maintenance and renewal of permanent way and works; and, the number of miles maintained; 3rd, the train mileage; 4th, the gross tonnage, together with other information bearing upon the subject.

The diagram relating to the London and North Western Railway was then explained in detail, and it was remarked, that the cost of maintenance of way had reached £270 per mile per annum, that of staff and other charges had been regular and uniform throughout down to the present time, that the item works of line showed considerable variation, due probably to the heavy expenditure at times in replacing timber viaducts and repairing slips, and that stations and station works also exhibited the same variable character. It was, however, in the last item, renewals of way, that the principal disturbance of outline was noticeable. This was alluded to in periods in the Paper and the gross result arrived at was, that in the nineteen years £1,906,850 had been expended on renewals of way alone, representing something like 1,362 miles of single line, or almost one-half of the whole mileage maintained in the year 1865.

This gave an annual average, since 1847, of £103,000, which was equivalent to nearly 73 miles of single way of the main line broken up and entirely replaced annually during the period referred to; chiefly in situations where the traffic was heaviest, and where consequently, owing to the short intervals between the trains, the facilities for doing the work were the least and the danger of accident the greatest.

The average cost of renewals per mile per annum during a period of years, on the nine railways to which the statistics related was shown in the following table:—

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of Railway</th>
<th>Average Cost per mile</th>
<th>Cost per mile per Annum.</th>
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<tr>
<td>1.</td>
<td>London and North Western</td>
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<td>2.</td>
<td>North Eastern</td>
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<td>3.</td>
<td>Midland</td>
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<td>4.</td>
<td>London and South Western</td>
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<td>5.</td>
<td>Great Northern</td>
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<td>6.</td>
<td>Lancashire and Yorkshire</td>
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<td>7.</td>
<td>South Eastern</td>
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<td>8.</td>
<td>London, Brighton and South Coast</td>
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<td>9.</td>
<td>Manchester, Sheffield, and Lincolnshire</td>
<td>...</td>
<td>£49</td>
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As the Diagrams and Tables already described were too general in their character to enable a reliable estimate to be formed of the “life of a rail,” the Author, with the assistance of Mr. R. Johnson (M. Inst. C.E.), had supplemented those
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relating to the Great Northern railway, by longitudinal sections of the two principal divisions of the main line, from King’s Cross to Peterborough (75½ miles), and from Peterborough to Askern junction (84½ miles), showing the places where the renewals had occurred, the periods of renewal, and the nature of the different geological formations. Here it was that the destructive effects upon the permanent way of a large and concentrated traffic, more especially of a heavy and rapid coal traffic, were most significantly evident. Various modifications had been rendered necessary in the way as originally laid, and the rails and chairs now used in renewing the road were of a heavier character, and the sleepers were of a larger scantling and were placed closer together. The cost of renewing a single mile of track on the principal line, excluding the small credit being allowed on the old materials, was now estimated at £1372. It appeared that during the last twelve years 315 miles had been entirely renewed on the main line between King’s Cross and Askern junction, at an expenditure of £235,850, being at the rate of £735.27s. per annum, which was equivalent to upwards of 1 per cent on the ordinary stock of the Company. In other words, the renewals on the 160½ miles during the period mentioned had amounted to an average cost of £200 per mile per annum. It was explained that the up traffic, including as it did the whole heavy coal trains, exceeded that on the down line nearly in the ratio of 2 to 1; and, as might naturally be expected, the cost of maintenance and renewals on the up line had been in the same proportion, as 203 miles on the up line having been re-laid, and 112 miles on the down line. Where the different streams of traffic converged, as for instance at Hitchin and Hatfield, the frequency of the periods at which renewals had occurred became very apparent; for the greater part of the up line, on the descending gradients between Potter’s Bar and Hornsby, had already undergone a third renewal during the short period of thirteen years, giving an average of only three and a-half years as the life of a rail under these exceptional circumstances. From a return, furnished by Mr. Grinling, it appeared that, on the up line near Barnet, 57,350 trains and 11,790,926 tons had passed over the portion of the line for the 13 years the rails laid in 1857, and that 65,599 trains and 13,434,661 tons those laid in 1860 and taken up in 1863.

The results of an investigation made by Mr. Meek, extending over a period of seven and a quarter years, showed that on the Lancashire and Yorkshire, where the traffic was of a heavy character, but conveyed at a slower speed as compared with the Great Northern, on the falling gradient of 1 in 130 at Ramsbottom Viaduct, between Bury and Accrington, 62,399 trains and 12,451,784 tons were worn out the best sample of rails in seven and a quarter years. At Bolton, on the level, where all trains drew up, the same description of rails had required 2,079,122 trains and 48,906,128 tons to wear them out in a similar period. This anomaly of the Lancashire line was clearly proved, that the rapid deterioration of the permanent way was in a great measure attributable to the increased weight and speed of the traffic; and that the concurrence of the tonnage outlines with the cost of renewals was collateral evidence of the truth of these deductions. It was contended that the chief material, the rails, was wanting in the essential element of durability, and that the experiments on the Lancashire and Yorkshire showed that both the best Yorkshire iron and the coupler and harder descriptions of Welsh manufacture, were alike incapable of withstanding for any length of time the excessive wear and tear to which they were exposed. The mode of manufacturing iron rails by various methods of forming the pile, adopted at the principal iron works in South Wales, were, then described. It was stated that very few makers were now disposed to give even a seven years’ guarantee for iron rails, which was tantamount to an admission, that when exposed to the excessive wear and tear of main line traffic, their employment must no longer be looked for. The introduction of steel rails, manufactured chiefly by what was known as the Bessemer process, and the satisfactory nature of the results obtained, encouraged the belief that in this material had at length been obtained, what was alone wanting to give something like real permanence to that which alone had hitherto deserved the title of permanent way. Two steel rails laid in May, 1862, at the Chalk Farm Bridge on the London and North Western Railway, side by side with two ordinary iron rails, after outlasting sixteen faces of the iron rails, were taken up in August last, and the one face only which had been exposed, during more than three years, to the traffic of 9,550,000 engines, trucks, &c., and 98,577,240 tons, although evenly worn to the extent of a little more than a quarter of an inch, still appeared to be capable of enduring much more work. A piece of one of these old rails was exhibited by Mr. Kirkaldy’s machine, the results being recorded in tables and diagrams, showing the comparative strength of steel, steel-topped, and iron rails of different sections.

The general adoption of steel rails on main lines, where the traffic was of the heavy description referred to, would, in the opinion of the Author, not only prove cheaper in the end, but what was of infinitely greater importance, would through the less frequent breaking up of the road, materially, add to the safety of the travelling public. A tabular statement, which had been prepared by Mr. K. Johnson (M. Inst. C.E.), of the cost of using guaranteed iron at 7s. 8d. per ton, and estimated to last three years, and of steel rails at 15s. per ton, supposed to last twenty years, showed a balance of fifty per cent, in favour of steel rails.

CHRIST’S COLLEGE, BRECKNOCK.

(With an Engraving.)

The group of buildings of which we give a view and plan in the accompanying illustration have lately been completed, and are now opened as a public grammar school, of which the Rev. John D. Williams, M.A., is the head master for forty boarders, with masters’ residence, and school and class rooms on a scale sufficient to receive a considerable number of scholars resident in the town of Brecon and its neighbourhood, besides those who are boarders in the establishment. The site of the buildings is just outside the town, on the Merthyr-road, among the farmland and meadows of the Brecon Beacons. This position was fixed by the ancient buildings belonging to the College, which have been restored, utilised, and added to, to render them fit for their present purpose. These old buildings were the remains of a monastery suppressed in the reign of Henry the VIIth, and consisted of the nave and chancel arch, as is not infrequent in the locality, and there was a north aisle extending only as far as the nave, the treatment of which was very unique, as there are unmistakable proofs that it was lighted by a series of five large dormer gables, of which one gable (seen in the view) exists nearly in its original condition. Between the gables the aisle wall received the lean-to roof continuous with that of the nave. The walls which now form the western wall of the chancel, and enclose westwards the eastern portion of the aisle, as may be seen by the plan, date less than a century back, and the bell-turret upon the west wall of the chancel, the copings and cross of the eastern gable, and the side eavescourses and corbels, of the roof, are part of the recent works, all traces of original work having been previously destroyed. The interior of the chapel contains a founder’s monument, a beautiful range of sedilia and piscine, and rich arcades to the nave, the fifteenth century work executed in hard grey sandstone. The school room and library, which formed the principal apartments of the old Deenav house, still retain their noble oak roofs and stone chimney-pieces of fourteenth century work, and a few other old details.

The building in the centre of the group contains the boys’ dormitories, with a campanile tower over the general staircase. This has been omitted for the present, from the insufficiency of the funds. An octagonal kitchen projects from this building, and forms a prominent feature, as may be seen by the view. The masters’ house is the furthest portion of the group.

The expenditure up to the present time has been about...
£10,000. The buildings were erected from the design of Mr. John Prichard, then of the firm of Prichard and Seddon of Llandaff. The chapel contains some striking stained glass by Messrs. Clayton and Bell, and rich tile decoration by Mr. Godwin of Lugwardine, from designs by Mr. Seddon.

References to Plan.

a. School room.  r. Boots.
b. Library.  s. Hall pantry.
c. Class room.  t. Matron's store.
d. Dining room.  u. Beer cellar.
e. Dining room.  v. Root house.
f. Study.  we. Wood and coal.
g. Kitchen.  x. Yard.
h. Matron's room.  y. Back yard.
i. Servants' hall.  z. Lavatory.
j. Stores.  z. Stairs and closets.
k. Staircase hall.  z. Ash pit.
l. House pantry.  A. Site of nave and aisle of the old church.
m. Scullery.  B. One bay on side now enclosed.
o. Larder.  c. Chapel, originally chancel, of the old church.
q. Cook's pantry.

THE CATHEDRAL OF ST. CANICE, AND OTHER ARCHITECTURAL ANTIQUITIES, KILKENNY, IRELAND.*

By T. Newsham Drake, F.R.I.B.A.

The Cathedral of Kilkenny being now in process of restoration many things have been brought to light connected with its original design, which may make a short paper on the subject interesting to the Institute. In connection with the description of the Cathedral, I purpose touching briefly on the other buildings of interest which still exist in Kilkenny—ecclesiastical, military and secular.

Under the first of these heads I would enumerate the Cathedral; the Augustinian Abbey of St. John the Evangelist, whose charter, in the "Monasticom," is dated 1220, founded by William Marshall, the elder, Earl of Pembroke; The Dominican Abbey, founded by William Marshall, the younger, 1225, dedicated to the blessed Trinity, commonly called the Black Abbey; the Franciscan Abbey, founded 1230; St. Mary's Church, probably finished 1228; the Vicar's Hall, near the Cathedral, and other buildings forming part of the Cathedral establishment.

Under the second head, the Castle forms the most interesting object of attention. Under the third head, I would mention the Hospital founded by Sir Richard Shee, 1651, and several houses dating from the Sixteenth Century and onwards.

The Cathedral.—A full description of this beautiful and interesting structure has been given by the Rev. James Graves, in his book on "History and Antiquities of Kilkenny," from which, and other authorities, I have made a few notes. St. Canice, to whom the church was dedicated, was a man of distinguished piety, the intimate friend of St. Columbkill, on the model of whose foundation at Iona he founded a monastery at Agaboe, in Upper Osory, which existed in 577. The earliest allusion to Kilkenny, in "The Four Masters," A.D. 1085, mentions that Cael Cainnagh, or the Church of Canice, was partly burnt—probably a wooden structure, which was shortly after rebuilt, and destroyed by fire 1114. After this second destruction, it appears to have been raised again, of more costly materials. Numerous carved stones, of twelfth-century work, have been built into the walls and under the paving of the present church; and extensive foundations at the eastern end of the Cathedral indicate that a church of that period existed. In 1189, William, Earl Marshall the elder, through a marriage with Isabella, only child of Richard FitzGilbert, Lord of Osory, became Earl of Pembroke and Lord of Leinster. With this nobleman came into Kilkenny, in 1183, the Bishop of Limerick, who was appointed Governor of the Kingdom of Osory, by Prince John, 1191—Richard I. being then in exile. He erected the castle 1192, returned to England 1194, came back to Ireland 1207, rebuilt the Castle of Kilkenny, and gave a charter to the town, under which it still enjoys certain privileges. In 1203, we find the see of Osory at Agaboe, St. Canice's original foundation, under the prelacy of Felix O. Dullany, who was succeeded by Hugh Rufus, or De Rou, an English Augustinian canon, and in 1206 the first English grant of the see of Osory was made, the church of Kilkenny and the whole of the lands of Agaboe for others at Kilkenny, belonging to the Lord of Leinster, and probably used the church which he found on the site of the present cathedral, as it is stated "he did nothing further for his episcopal see." From manuscripts in the Ormond Collection, we find that a cathedral existed 1209. This was the ancient church of Dullany's time, or the choir of the present church, used as a cathedral prior to the completion of the structure. Bishop Hugh de Mapleton carried on the work with great vigour from 1251 to 1256, and nearly brought it to a finish. Geoffrey St. Leger, 1260, completed the cathedral, at great cost by the foregoing reason. From this time that the present structure in its walled features, was built between the years 1251 and 1260, and possibly may have been commenced before 1229. In 1323, we find that the belfry fell, breaking the side chapels. For twenty years the cathedral remained in a ruinous condition, when, in 1564, the tower was restored, the vaulting of which was put in by Bishop Pococke; (this paper was an architect of the Cathedral of Bath, in England). 1491, Bishop Bedrid filled the windows with beautiful stained glass, particularly the eastern ones, which represented the whole life of Our Lord. So beautiful were they that Bannuccini, the Pope's Nuncio, who saw them in 1645, offered £700 for the same class, which was declined by the then Bishop of Kilkenny, James Roth. In 1650, those windows were demolished by Cromwell, who broke the monuments and "took away the great and goodly bells, and threw down the roof thereof." On the 12th of August, 1658, the Commonwealth passed an Act for the Repair of Churches, which does not appear to have taken effect on the Cathedral. In 1660, Bishop Willams, finding the church in this ruinous condition, commenced to repair it, etending on the choir alone £400. From this date until 1672, the Cathedral underwent sundry repairs, and was supplied with a ring of four bells at a cost of £246 13s. 10d. In 1677, Bishop Parry supplied plate, value £100; and, 1756, Bishop Pococke, finding his cathedral almost totally neglected, its roof tumbling down, and its monuments broken, commenced the work of renovation, and with the assistance of his chaplain placed the Cathedral in the condition in which it has been handed down to us when the present restoration was commenced. The fittings of the choir put up by Bishop Pococke, being of a Grecian character, were quite at variance with the architecture of the cathedral, as well as the monuments which ornamented the choir. In 1863, the roofs were found to be much decayed, and it was then determined to restore the church, as far as possible, to its original condition.

The accompanying plan gives the general arrangement and principal dimensions of the Cathedral, which is the finest of magnitude in Ireland. The total length is 92 feet, breadth at transept 128 feet. The chapels on either side of the choir, marked upon the plan H and K, have given rise to various discussions as to their use, until the present alterations were commenced, the only access to these was through small doors, one opening from the north transept, the other from the Lady chapel. The removal of the old plaster on the roof disclosed the fact that these chapels were divided from the choir by large arches, with beautiful mouldings and corbels. Similar arches opened into the transepts. The fall of the tower, in 1369, carried in its ruin part of the adjoining arches and walls of choir and transepts: when the tower was rebuilt, the injured walls were carried up in solid masonry, and thus the arches alluded to were blocked up. One of the principal features in the present restoration is the rebuilding of these arches, completing their mouldings and corbels. The clerestory windows of choir, fire at either side, which were also built up, are likewise being restored. The choir appears to have undergone several changes, shortly after its erection in the thirteenth century: for instance, the Lady chapel, although a beautiful specimen of early English work, has clearly been an addition, as the wall of side chapel, shows indications of a continuous arcade of arches, proving it to have been an outer wall. Almost all the windows in the Cathedral have detached and filleted shafts. The east end of choir is very beautiful, having nine lights, with detached and

* Abstract of a Paper read before the Royal Institute of British Architects,
filleted shafts, heads cupped on interior, and semicircular on exterior. The windows were originally filled with the stained glass, so much admired by the Papal Nuncio, and for which he offered so large a sum in 1660. Funds for the restoration are too limited to allow of those large windows being restored. It is, however, hoped that persons interested in the work may be induced to lend their aid to the accomplishment of this part of the restoration.

The Lady Chapel, owing to defective foundations, has had to be rebuilt, the stones being numbered and used in the work. A complete arcade of arches runs round the two external walls, south and east. On the former there are nine lights, in groups of three, these drop arches to the interior with marble pilasters and marble capitals. To the east, six lights, grouped in pairs, with drop arches and pillars. This portion of the building will be used as chapter-house.

A small chapel used as the parish church and the two side chapels have each their ambry and piscina. On the south side of choir has discovered the site of the sedilia; sufficient indications of the designs remain to enable it to be correctly restored. Higher up, beneath the side windows, are two recesses—the one an ambry, the other a piscina.

The carved capitals to windows of the side chapels are interesting, as giving a certain weight to the theory put forward by Mr. Skidmore, that early English foliage takes its type from nature and not from capital and records it as it were, with a hoop. These windows are being carefully restored, no stone being cast aside which can possibly be re-used in the work. On the walls of side chapels the original decoration has been discovered—scrollwork of excellent design in black, orange, and green, running under the wall-plate, the walls covered with what may be called an ashlar pattern. It is proposed to carry out the same mode of decoration in the new work. The roofs of the side chapels owe their design to the only remains of an early English roof I have seen in Ireland, that of Callan Church, removed some years ago.

The roofs of the whole church are new, stone gutters having been placed throughout, behind the pendants, which are embattled—the most usual finish for ecclesiastical buildings in Ireland; still, I am of opinion that such was not the original design, but probably dates from the fourteenth or fifteenth century, portions of tombstones of an early date forming part of their structure. Still, they are of sufficient antiquity, and nationalities in their character, to make it desirable to maintain them.

The porch is interesting as having been, in 1475, the scene of the murder of Richard, the son of Edmund Mac Richard Butler, in revenge for a similar outrage enacted thirty-five years before under his direction. The mouldings of the entrance archway are very beautiful, and busts, which are introduced in the ceiling, are carved on the cloaks what is now known in Ireland as the Tara Brooch.

On removing the pavement, several patterns of ancient tiles have been discovered, some of which have been forwarded to Messrs. Minton, with a view to their reproduction. The device is generally incised, four tiles forming the complete pattern, two glazed with a black glaze and two with red. A similar pattern has also been discovered, all red. Several stone coffins have been brought to light; and an effigy, face downwards, forming part of the modern paving, has been revealed. On opening an ancient vault, which is supposed to have belonged to the Ormonde family, a leaden coffin was discovered. The profile of the body, having been copied in lead, formed the upper portion of the coffin; the under portion is shaped in such a manner as would have fitted into the hollow of one of the stone coffins which have been dug up. In this same vault a leaden urn, supposed to contain the heart of Viscount Mountgarret, was discovered.

In examining the ruins of Ireland, it is interesting to trace the debased character of design and workmanship in various districts. In Kilkenny I trace the workmen who were employed at Christ Church, Dublin, and probably at Boyle Abbey—the filleted shaft and writhed angle shaft, as in north transept doorway, are to be found in all three. In Co. Galway, the tracery of altar tombs and windows evinces that the same minute work, if executed by trained masons, would appear in the work of the Kilkenny craftsmen. In mentioning this, I do not wish to infer that one thing is a servile copy of another, but that there is sufficient to lead the enquirer to the conclusion that certain men carried their art from place to place, and were esteemed for their talent in architectural construction.

The general details of Kilkenny Cathedral are much simpler than is usual in English churches, owing to the hardness of the clays employed, and the heavy masses, as well as the proportions, as in most Irish churches, are very good, and the strength and massiveness of the work give an idea of size which elaborated tracery and multiplicity of mouldings, would not have produced.

The work of restoration has been pressed on with vigour. The roofs are finished, the arches between the choir and side chapels opened, the prebendal stalls in hand; still, much remains to be done. The tower must rest in its present unfinished state until funds are collected for its completion. Considerable portions of the common hall still exist, particularly the gable end, which has a very interesting window.

At the north-west angle of the Cathedral Close is the library, founded by Bishop O'Dwyer, 1673. In mentioning the mode in which its bequest was to be expended, he enumerates 'claims for every particular book.' At the eastern corner of the south transept stands one of the round towers almost peculiar to Ireland, and so ably written on by the celebrated antiquarian, Dr. Petrie, whose theory that they are of a Christian origin is, in my opinion, confirmed by the following facts. The tower, which is one hundred feet in height, was filled to a considerable depth with accumulated rubbish, principally the deposit of birds. This was removed, and on digging two feet below the outside level, human remains were discovered, contained in wooden coffins, placed partly under the foundations. The tombs must have been erected on, or nearly on, the surface of the ground, which ground must have been a place of burial previous to its erection; and the position of the remains, with reference to the points of the compass, indicates that they were those of Christians. It is curious that a structure of such height and small base, should have stood so well, resting on such a foundation.

PRIORY OF ST. JOHN—The oldest monastic foundation in Kilkenny is the Priory of St. John, founded by William Marshall, the elder, earl of Pembroke. In 1645, when the abbeys of Ireland were everywhere being restored, the Augustinians claimed their abbey; but the Jesuits, being the more powerful body, opposed the claim, and were confirmed in their occupation by Bianuccini, the Pope's Nuncio. Dr. Ledwic states that a portion of the abbey was pulled down to make room for an infantry barrack. Sufficient however, remains to show much of its original extent and beauty. Fifty-four feet of south side of choir is a continuous arcade of lancet windows, the largest pier being only nine inches wide. It is to be regretted that the preserving this portion of the building, the windows have been cut down, especially the eastern one, and every second light stopped up. These ruins contain several monuments and effigies of great interest. The design of the chapter house at the Cathedral was taken, evidently, from the choir of St. John's.

The Franciscan Abbey, situated among orchards near the river, exhibits some interesting details. The east end is lighted by five lancets. The choir and tower of this abbey alone remain.

The Dominican of Black Abbey, founded by William Marshall, the younger, 1325, has lately been restored by J. J. MacCarthy, Esq., Architect. The general plan is indebted for the plan which accompanies this paper. It is interesting as showing how the simple form of the Dominican or Franciscan churches were added to, the most usual shape being two parallel-logs, nave, and choir, sometimes with a narrow tower between. Frequently this tower is an addition. In the present instance the choir has been extended to aisled transept and nave. The top of the tower is a particularly good specimen of crenellated battlement and threaded roof.

St. Mary's has little of its original architecture worth describing; the church has been completely modernized. Surrounding the church are several tombs of great interest, principally of the fifteenth and sixteenth century, belonging to the families of Archer and Sice.

(To be continued.)
CELESTIAL PHOTOGRAPHY.

By A. Brothers, F.R.A.S.

The credit of having produced the first photograph of a celestial object is generally given to the late Mr. Bond, of Cambridge, U.S.; but it appears from a paper by Professor H. Draper, of New York, published in April, 1864, that in the year 1840 his father, Dr. J. W. Draper, was the first who succeeded in photographing the moon. Draper states that to have made an unsuccessful attempt to photograph the moon, but that he has been unable to ascertain when this experiment was made. Mr. Bond's photographs of the moon were made in 1850. The telescope used by him was the Cambridge (U.S.) refractor of 15 inches aperture, which gave an image of the moon at the focus of the object glass 2 inches in diameter. Daguerreotypes and pictures on glass mounted for the stereoscope were thus obtained, and some of them were shown at the Great Exhibition of 1851, in London. Mr. Bond also proved the advantage to be derived from photographs of double stars, and found that their distances could be measured on the plate with results agreeing well with those obtained by the meridian method. Between the years 1850 and 1857 we find the names of Father Secchi in Rome, and M.M. Berch and Arnauld in France; and in England Professor Phillips, Mr. Hartnup, Mr. Crookes, Mr. De la Rue, Mr. Fry, and Mr. Hoggins. To these may be added the name of Mr. Dancer, of Manchester, who, in February 1853, used some negatives of the moon with 4 inches object glass. They were small, but of such excellence that they would bear examination under the microscope with a 3-inch objective, and they are believed to be the first ever taken in this country. Mr. Baxendell and Mr. Williamson, also of Manchester, were engaged about the same time in producing photographs of the moon.

The first detailed account of experiments in celestial photography which I have met with is by Professor Phillips, who read a paper on the subject at the meeting of the British Association at Hull, in 1853. Professor Phillips does not enter very much upon the details of his own work, but gives some very useful details of calculations as to what may be expected to be seen in photographs taken with such a splendid instrument as that of Lord Rosse. It is assumed that an image of the moon may be obtained direct of 18 inches diameter, and this when again magnified sufficiently would show black bars of 12 yards in length, if from the 18th century, while its active power is only 6 to 5, or 6 to 4. On December 7th, 1857, Jupiter was photographed in five seconds and Saturn in one minute, and on another occasion the moon and Saturn were photographed just after an occultation of the planet in fifteen seconds. The report of the council of the Royal Astronomical Society for 1858 contains the following remarks:—"A very curious result, since to some extent confirmed by Professor Secchi, has been pointed out by Mr. De la Rue, namely, that those portions of the moon's surface which are illuminated by a very oblique ray from the sun possess so little photogenic power that, although to the eye they appear as bright as other portions of the disc normally illuminated, the eye would produce the effect called by photographers 'solarisation,' before the former (the obliquely-illuminated portions) can produce the faintest image." And the report also suggests that the moon may have a comparatively dense atmosphere, and that there may be vegetation on those parts belonging to the near side of the moon. At the meeting of the British Association at Aberdeen, in 1859, Mr. De la Rue read a very valuable paper on celestial photography. Mr. De la Rue commenced his experiments about the end of 1852, and he used a reflecting telescope of his own manufacture of 13 inches aperture and 10 feet focal length, which gives a negative of the moon averaging about half an inch in diameter. The photographs were first taken by reflecting the image of the tube after the image had been twice reflected. This was afterwards altered so as to allow the image to pass direct to the collodion plate, but the advantage gained by this method was not so satisfactory as was expected. In taking pictures at the
side of the tube, a small camera box was fixed in the place of the
deye-piece, and at the back a small compound microscope was
attached, so that the edge of a broad wire was always kept in
contact with one of the craters on the moon's surface, the image
being seen through the collodion film at the same time with the
wire in the focus of the microscope. This ingenious contrivance in
the absence of a driving clock was found to be very effectual,
and some very sharp and beautiful negatives were thus obtained.
Mr. De la Rue afterwards applied a clockwork mechanism to the
telephoto for these purposes. The two instruments that were sent
are as yet the best ever obtained in this country. The advantage
of the reflecting over the refracting telescope is very great, owing
to the coincidence of the visual and actinic foci, but it will
presumably appear that the refractor can be made to equal if not
exceed the reflecting one, if the same amount of actinic window
subject of celestial photography, I have not referred to anything
which has been done in making photographs of the solar spots,
but the matter must not be altogether passed over. The first
step in this direction appears to have been taken in France, in
1843, by MM. Fizeau and Foucault, but it is chiefly due to the
efforts of Mr. De la Rue that so much useful work has been done
in heliography. In 1850 Mr. De la Rue and his staff of assist-
ants performed one of the greatest feats yet recorded in this
branch of the art of photography, having succeeded in obtaining
several beautiful negatives of the various phenomena seen only
during total eclipses of the sun, and two negatives were obtained
during the eclipse of March 6th, but in this case, the actinic window
was determined by this great experiment. The red
prominences or flares generally seen as issuing from the edge of
the moon were proved to belong to the sun. Photographs of the
sun are taken daily, when the weather is favourable, at the Kew
observatory, and also by Professor Selwyn, at Ely. With the
Kew instrument it is possible to take negatives on the scale of 3 feet
to the sun's diameter. Much, however, remains to be done. The
light of the sun is much in excess of what is required to obtain a collodion picture, so that the loss of light consequent on the necessary interposition of lenses, and the
distance of the plate from the instrument, can be no objec-
tion. One question that much interested astronomers was the
sparatus suitably arranged, photographs of spots and groups of
spots will be obtained of very much larger diameter than any yet
taken.

The 'Quarterly Journal of Science,' for April 1864, contains
the next important paper on celestial photography, by Dr. Harry Draper, one of the Professors at the New York University.
On his return to America, after paying a visit to Paris-town,
where he had the advantage not only of making some observa-
tions with Lord Rosse's large reflector, but also of seeing the
method there pursued in gridding and polishing mirrors, stimu-
lated the student to work. He made use of a long plate, it was
formed into a paraboloid, and constructed an instrument to be devoted solely
to celestial photography. The speculum used by Dr. Draper is
15½ inches in diameter, and 15 feet focal length; but this was
afterwards superseded by one of glass on Foucault's principle.
The great labour involved in a work of this character may be
judged of by the fact that Dr. Draper ground and polished more
than 100 mirrors, varying in diameter from 19 inches to 2½ inch;
but he appears at last to have secured a good instrument. The
chief points to be noticed in this article are, that instead of
driving the telescope in the usual way by means of a clock, the
frame carrying the glass plate was made to move on the plan
pursued by Mr. Monck, the object used instead of this was a
piston called a "pleysnyr," a cylinder filled with water, which
is allowed to escape by means of a stopcock, and can be
regulated with great exactness, so as to follow the object. The
large number of 1500 negatives are stated to have been taken at
this instrument, which shows the minimising of the actinice diameters of
five diameters (the paper says, times, but I assume this to be an
error, as a negative must be very bad if it will not bear more
than five diameters, or twenty-five times). As the average size
of the negatives was 1½ inch, an increase of twenty-five diameters would give an image of the moon nearly 3 feet in
diameter, and I may mention that the three negatives having
never heard anything of the quality of the work produced by
this telescope; but it may be stated that Dr. Draper writes as
if the negatives were of the best quality, and encourages others
to follow his example. Nearly a quarter of a century has elapsed
since the moon was first photographed in America, and our
friends on that side of the Atlantic have not been idle in the
interval. To an American gentleman we are indebted for the
best pictures of our satellite yet produced, and it is difficult to
denounce a man that anything superior can ever be obtained and yet
with the fact before us that Mr. De la Rue's are better than any
others taken in this country, so it may prove that even the
marvellous pictures by Mr. Rutherford may be surpassed.

Mr. Rutherford appears, from a paper in the 'American Journal of Science,' for May of the present year, to have begun
his work in taking pictures of the stars, planets, and the lunar
coronal of 11½ aperture, and 14 feet focal length, and corrected in the
usual way for the visual focus only. The actinic focus was found
to be y5 inch longer than the visual. The instrument gave
pictures of the moon, and of the stars down to the fifth magni-

It was a matter of surprise that so much good detail had previously been done, but did not satisfy Mr. Rutherford, who, after trying to
correct for the photographic ray by working with combinations
of lenses inserted in the tube between the object glass and
the sensitive plate, commenced some experiments in 1861 with a
silvered mirror of 13 inches diameter, which was mounted in a
frame and strapped to the tube of the refractor. Mr. Rutherford
enumerates several objections to the reflector for this kind of
work, but admits the advantage of the coincidence of foci.
The reflector was abandoned, and a refractor specially constructed
of the same size as the first one, and nearly of the same focal
length, but corrected only for the chemical ray. This was made that anything superior can ever be obtained and yet
with the fact before us that Mr. De la Rue's are better than any
others taken in this country, so it may prove that even the
marvellous pictures by Mr. Rutherford may be surpassed.

Every writer on this subject speaks of the difficulties encon-
tered from optical, instrument, and atmospheric causes; and
the fact that at times amateurs, astronomers and their friends,
have given their attention to the subject.

Another reason may be that comparatively few of those who
possess telescopes may have the necessary photographic know-
edge; but surely some friend having this knowledge might be
found who would be willing to spare a few hours occasionally
taking pictures if the instrument is pointed to the moon or
another object of interest. The reason, then, why this subject is
brought before your notice in this paper is, that it is believed that the apparatus
I use is—in some particulars—more simple than any heretofore
described, and as it can be used with any kind of telescope, a
great deal of amateur work can be engaged in it, and it may
be induced to follow this fascinating branch of photography.
It will have been noticed that when particulars of the apparatus
have been given, the writer has spoken of a small camera, which
does not fix the eye of the telescope. Also how this was effected I have seen no description, and as no camera
was used, it would enter into my plan to describe the mode in which it may be done. Before deciding what
necessary to be done, it occurred to me that the telescope itself was the camera, and not that was required was the
meat of fixing the dark frame or plate holder. If the telescope
pointed to the moon, the eye-piece removed, and a piece of
glass held between the eye and the aperture, the image
will be seen on the glass, and we require then the means
of holding the sensitive plate steadily near the same place.
A that is needed is a brass tube about four or five inches long
of the size exactly fitting the tube of the telescope in the place
of the eye-piece. In some cases the sliding tube of the eye-piece
will be found the most convenient, in which case a piece of metal
plate (in the centre of which is a circular aperture of the
same size as the tube), of the same dimensions as the dark
frame. Attached to the plate holder are clips accurately fitting
the brass plate, but so that the frame will easily slide on and
off, without disturbing the sensitive plate. An additional
apparatus required to enable photographs of the moon or any
other celestial object to be made. A separate frame for
the ground glass is not necessary; it must be cut to fit the
dark frame, and while in use can be held by slight springs fixed
inside the frame at the sides.

The position of the actinic focus may be stated
in a few words. With the rack motion adjust the focus for
distinct vision on the ground glass, and then mark the
and also the sliding part of the telescope. Although very
unlikely to be of the slightest use, unless taken with a reflecting
telescope, a picture may now be taken; it will at least serve to

give some idea of the proper exposure. If the chemical and visual foci are not coincident the image will have a blurred appearance. Before exposing the next plate turn the adjusting screw as far as is possible for light from the image of the moon for 15 minutes and so proceed until, by the greater distinctness of the image, it is seen that the chemical focus is found. At every change of the focus a slight mark should be made on the tube, and when the true focus is satisfactorily determined the marks should be made distinctly visible; and in all future experiments with the same focus the focus will be always at the same place. Should it be found that the distinctness increases, it will of course be found necessary to try in the other direction. The appearances arising from atmospheric disturbances are very much the same as when the object is out of focus; experience alone will enable the operator to determine from which may be assumed that the telescope is provided with a driving clock; when such is the case every care should be taken that all the parts are clean, and, when necessary, oiled or greased, so that the motions may be as smooth as possible.

In photographs of the moon in the phases prior to and after the full, the side opposite to the sun is always too light or "burnt up," while those parts near the terminator are often so dark that only the tops of the craters and peaks are visible, although in the telescope a clear and bright image can be seen. The cause of this must be that the exposure is too short or the reversal of the eye can see on the darker side, would entirely extinguish the details on the brightly illuminated portions of the moon's surface. Mr. De la Rue's suggestion as to why the dark side of the moon has so little actinic effect, has been already referred to. I would suggest that, as the light of the full moon is 100,000 times weaker than that of the sun, the light of the moon's surface must be very much less, and consequently the actinic effect of the light is lessened in the same way as at a corresponding time of day. The question, then, of photographing the terminator is only one of time, and in order to remedy the defect spoken of to some extent, I have used diaphragms such as are shown in the engraving, and in order to get the opposite side, and wide enough to admit the diaphragms to be used without touching the tube. The diaphragm must be of proper length and width to shut off the moon's light until the plate is ready for exposure. The shape of the diaphragm will suggest which form should be used according to the moon's age. The exposure should be made with the full aperture for as many seconds as previous experiments have proved to be necessary for the bright side, and the diaphragm then gently moved and kept in motion, gradually approaching the darkened side. By this means the exposure may be regulated, and the great differences in the light and dark sides of the moon may be modified.

As to the subject of photographic collodion, the experimenter must adopt the one he finds in his hands gives the best result. It seldom happens that two operators can produce the same effects with apparently the same chemicals. Experience has shown me that the ordinary patent glass plate (carefully selected, so as to be free from scratches and other defects) is preferable to the white patent plate, having found that after a time the surface becomes covered with a kind of dew, or "sweat," as it is termed, owing to the decomposition of some of the salts used in the manufacture. The collodion used was made for me by Messrs. Huggon and Co., of Leeds; it is very quick, free from structure, and suitable for iron development. To develop with an iron solution, using only sufficient to cover the plate, the developer is applied several times with the bath and collodion exactly in the proper state, there is no doubt that with bichromic acid negatives may be had as quickly as with iron; but it is extremely difficult to have everything constantly in the best working order. Unless the greatest attention be given to this matter, the time of exposure is so much increased, that iron, for this reason, must have the preference. Upon the character of the image after development entirely depends the value of the enlargement to be made from it, and in this direction there is much room for improvement in the best negatives, yet made defects from this cause are very apparent. The microscopic photographs by Mr. Dancer have the finest texture, and will consequently bear greater magnifying than any other photographs I have ever seen, but the process by which they are made is not published.

The weather in this country is so very uncertain, and success in this branch of photography is so entirely dependent on the state of the atmosphere, that it is necessary to be always prepared to take advantage of a favourable night. I have a small cupboard placed in a convenient part of my house, where there is a supply of plates and tools, and the air is taken from the air outside. This cupboard is just large enough to hold a small bell-fax at the proper angle ready for use, also the bottles for collodion, bath, developing and fixing solutions, and other little requisites. This arrangement is so convenient, that when there is a prospect of getting a negative I can set the telescope, prepare the plate, and take a negative in less than ten minutes. But when there is a chance of two or three hours' work an assistant is desirable, as the best results can only be obtained when one's attention is chiefly devoted to the careful adjustment of the apparatus connected with the telescope. The convenience of the plan adopted may be judged of by the fact that, on the evening of the 13th of August, the eclipse of the moon was to last four hours I succeeded with the help of two assistants in taking less than twenty negatives, and the telescope was several times disturbed to oblige friends who desired to see the progress of the eclipse through the instrument, but the apparatus was quickly readjusted, although possibly in some cases with slight negative, through haste. At a previous meeting I described how these negatives were made, but it may be interesting to refer to the fact that, while the fifteenth of the series was taken the telescope was at rest. The clock had been disconnected for readjustment, and it was forgotten when the plate was ready for exposure, consequently the moon had moved many degrees off the plate and the negative shows a portion of the moon's surface which the exposure was so short that the eye fails to detect any difference in the sharpness of this and the others, which were all taken when the clock had been watched and carefully regulated for the moon's motion. This fact, I think, of some value, as it shows that about the time of full moon, when the light is of the greatest intensity, pictures may be made with telescopes not equatorially mounted. My telescope is a refractor of 5 inches aperture and 6 feet focal length, giving an image of the moon, averaging about 1/3 of an inch in diameter. The actinic focus is one-tenth of an inch longer than the visual. The plate Ag is of Munich manufacture, and is mounted by Mr. Dancer, the plate glass is of Munich manufacture, and is mounted by Mr. Rutherfod of London. The telescope has a polar axis. The hour circle is 26 inches in diameter, and is used also as the driving wheel, having teeth cut in the edge, in which a screw works, connected with the driving clock by a rod, and which can be instantly disconnected by means of a cam. The object glass is an excellent one, and the mounting is everything that can be desired.

The negative taken direct in the telescope is but one step towards what we require, that is, the enlarged copy on paper. From the small negative a positive on glass must be made, say of twice or three times the diameter of the original. It is then necessary to make the enlargement to be made; but I may remark that the negative should be placed with the film side towards the copying lens, and the resulting positive copy must also be placed in the same way. The enlarged copy or negative will then give the true telescopic appearance of the moon. In the print of the full moon by Mr. Rutherfod, the sky is never seen as it is represented. I have sometimes taken negatives on the positive print, and on the engraving that the dark side is not quite central with the telescope, so that by reversing the plate after one exposure a second picture can be taken. In photographing the planet Mr. De la Rue has allowed the object to move on for a few seconds, the telescope meanwhile being at rest, and thus four or five
negatives can be taken in a very short time on the same plate. It has occurred to me that by having a frame made "landscape" way, instead of upright, and in place of having four clips such as E, there might be a kind of groove at top and bottom, so that after taking the first negative, and the light shut off, by moving the plate about an inch, at least three negatives might be taken on the same plate—or a "shifting back" might be adopted. The advantages of this plan are that different exposures might be tried, and the development continued for the one or two which promised the best results. This method would effect a great saving of plate, and one of great importance. With a Barlow lens I have made some negatives, which have shown that when the same care has been taken to find the actinic focus negatives of a much larger size may be made, and in a very short time. The image is increased from 11-16ths to 12 inches, and the time of exposure at full moon was two seconds. The fittings of the lens are so arranged that three different sized negatives may be taken.

**UNSINKABLE OR RAFT SHIPPING.*

By Charles Atherton.

The aggressive powers of ordnance versus the defensive powers of iron armour plating still constitutes, after years of experience and much of our war conditions, an inquiry, the solution of which fluctuates with every alteration in that relative capacity of iron armour plating. The introduction of armour plating induced improvements in ordnance; the ironclad floating batteries, which successfully withstood the fire from the Kibburn Fort in 1855, originated and succeeded to the more effective gunnery of 1859. The resisting power of the iron plating was consequently increased, and the 44-inch armour of the "Warrior" was for a time invulnerable, until the gunnery of 1862 sent both shot and shell through the then most approved model of the "Warrior" target. Attention was then directed to improving the quality of the iron which constitutes the armour plating of ships. The relative efficiency of plates has been compared with reference to this inquiry, and in the lately launched ship "Bellerophon" the thickness of the armour plating has been increased to 6 inches, with an inner plate of ½, making 7½ inches; but now, again, guns throwing shot or shell of 320 lb. weight are found to prevail, and consequently the "Heracles," now being laid down at Chatham, is said to have been designed to carry armour plating of the aggregate thickness of 9 inches, but built to carry shot of 600 lb. weight are also being prepared, and 1200-pounders are said to be in contemplation, and with little doubt of their being successfully introduced, for the whole matter of practical gunnery, as respects the required quality of materials and the relative power of ordnance, produces a formidable object, is now prosecuted on principles based on the ascertained laws of progressive increase, whereby it is confidently expected that guns may henceforth be constructed of the required capabilities for penetrating any armour plating of which the thickness may have been determined upon. In short, practical gunnery seems now to have become one of the exact sciences in the prosecution of which, with a view to the attainment of any given result, there is no limit but cost. But this is not all. We have hitherto aimed at rendering only the sides of ships invulnerable, and granting that we may attain that end, what of it? What is there to prevent mortar practices being revolutionised, as has been the case with gunnery? Ships may be assailed by a new era in mortar practice, hurling down thunderbolts from above, smashing the deck, carrying all before them, and passing through the bottom of the assailed ship. No construction of vessel has yet been devised to meet this mode of attack, so manifestly possible, and the more probable, the sooner whatever adopted, will again necessitate the reconstruction of our ships of war. Yet, thus threatened from above, we are also threatened with being assailed from below. Ships are now being constructed with submerged peaks for bursting through the sides of vessels below the level of the armour belt—a foul blow insidiously applied, yet lawful by the code of relentless naval war. Then again, the possible introduction of the steam ram, with monstrous powers of collision, combined with explosion, is not to be ignored. Now, how are the effects of these aggressive forces to be met or averted?

* Paper read at the Royal United Service Institute.

and in reply I proposed the question—may not the principle of raft-like unsinkability be combined with the partial protection afforded by armour plating, by which combination the guns, mortars, and rams of our opponent may do their worst, but still we are not destroyable? By this device there may still be some chance of hostile ships being lashed alongside each other, and victory determined not by the fire of guns, or the bullying of the ram, but by the arbitrament of hand-to-hand personal prowess.

My purpose, therefore, now is, to bring forward for review the theoretical bases, a knowledge of which is necessary, in a practical point of view, to a due consideration of the question, whether resistance by armour plating being supplemented with the introduction of the principle of "unsinkability," does not afford the most available means as applied to ships of war for mitigating the horrors that may otherwise result from the deeds elemental of modern ordnance and modern device, consequently whereon it has already been publicly avowed, that hostile ships of war will scarcely be able to approach each other without one or the other being sent to the bottom. In pursuance of these views I proceed—

1. To explain the theoretical principle of procedure by which, as distinguished from other plans, I propose to effect the object of preserving ships and their precious cargoes by protection of shot or shell through the sides, deck, and bottom of the ship.

2. To give the theoretical elements, data, and calculations on which the efficacy of the proposed system is based, and show the general mode of practical construction by which the principle may be applied to mercantile shipping and to ships of war.

These devices have from time to time been adopted for mitigating the danger of sinking vessels, ships having from two to eight steam ships, are liable from the occurrence of leakage, rupture from striking on rocks, collisions with other vessels, derangements of machinery, and other accidental causes. These devices have hitherto consisted in dividing the ship into compartments and cellular divisions by means of water-tight bulkheads. Also, in constructing the ship with a double skin or shell, and dividing the space between the two shells into water-tight cells. These devices afford great protection against ordinary casualties, which usually occur singly, and affect the ship only at one spot; but such cases are not analogous to the dangers resulting from the repeated and continuous damages from shot and shell to which ships of war are exposed in action, and whereby all parts of the ship may be penetrated, lengthways, crossways, and vertically, through and through, in a single hour. Several such compartments or cells may be penetrated by a single shot and become immediately filled with water, and this being repeated, the burden of the ship increases, and eventually the ship finally sinks. This system of cellular air spaces may greatly mitigate the danger of sinking, and prolong the floating of the vessel, but it cannot be said that such ships are unsinkable by shot.

The system which I propose may be denominated the solid raft system, to distinguish it from the hollow cellular system above referred to, and it consists in combining with the structure of the ship such a quantity of solid and non-absorbent materials, lighter than water, as shall support the whole weight of the ship and its load, whereby the vessel shall not sink, though perforated in all directions by shot and shell, or cut down by the stroke of a hostile ram.

**Theoretical Elements.—**The practical construction of raft shipping with a view to carrying out the principle of "unsinkability," must evidently be based on calculations involving the weight or specific gravity of the materials of which the floating body is to be constructed, with reference to the specific gravity of the fluid on which it is intended that the vessel shall float, and which in this case we will assume to be fresh water, which will give about 2¼ per cent. of the displacement in favour of the buoyancy of the vessel when floating in ordinary sea-water. That is, a ship which would carry, say 1000 tons weight, on a fresh-water lake, will, at the same draught carry a load of 1054 tons at sea; and the materials used for ship-building being, as respects their specific gravity, of a fluctuating character, dependent on their quality and condition, it follows that different authorities have not always assigned the same specific gravity to timber of the same denomination. The following table is therefore annexed, as the basis on which the results put forward in this paper have been calculated:
### Cubic feet.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh water at 60°</td>
<td>1000</td>
<td>624</td>
<td>1000</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Sea water</td>
<td>1024</td>
<td>1.024</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrought-iron</td>
<td>7760</td>
<td>485</td>
<td>7760</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasoned oak</td>
<td>800</td>
<td>50</td>
<td>800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teak</td>
<td>704</td>
<td>44</td>
<td>704</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honduras mahogany</td>
<td>704</td>
<td>44</td>
<td>704</td>
<td></td>
<td></td>
</tr>
<tr>
<td>English elm</td>
<td>704</td>
<td>44</td>
<td>704</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasoned red pine</td>
<td>650</td>
<td>41</td>
<td>655</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; larch, and &quot; yellow pine</td>
<td>580</td>
<td>35</td>
<td>560</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; white pine</td>
<td>448</td>
<td>28</td>
<td>448</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; poplar</td>
<td>400</td>
<td>25</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cork</td>
<td>192</td>
<td>12</td>
<td>192</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Now, as the weight of any floating body is equivalent to the weight of the quantity of fluid displaced by the floating mass, it follows that the load which will be supported by a cubic foot of any material of less specific gravity than water, when floating on water, will be equal to the weight of a cubic foot of water less the weight of a cubic foot of the floating material; consequently, from the following table, we at once deduce the weight that would be supported by each cubic foot of the different materials referred to in the table, when immersed in fresh water, weighing 624 lb. per cubic foot. For example:

Each cubic foot of oak will carry a load of 624 - 44 = 580 lb.

Similarly, each cubic foot of mahogany carries a load of 624 - 41 = 583 lb.

Hence we deduce the following table, showing the number of cubic feet of each of these materials which, used as the buoyant material of raft shipping, must be employed to support each ton weight of load with which it will be burdened.

For each ton weight of load there will be required as follows:

<table>
<thead>
<tr>
<th>Cubic feet</th>
<th>If oak be used as the buoying material</th>
<th>179</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>teak</td>
<td>121</td>
</tr>
<tr>
<td></td>
<td>mahogany</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>elm</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>red pine</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>yellow pine</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>black pine</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>poplar</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>cork</td>
<td>44-36</td>
</tr>
</tbody>
</table>

Thus it appears that the advantages of cork as compared with oak for the floating material is as 179 to 44:36, or about 4 to 1, as respects quantity to be employed for supporting any given load, and as 60 to 44, or about 16 to 1, as respects the weight of material for any given load. But cork, or any other material of the same specific gravity as cork, may require the support of some bonding material to give it the solidity which is desirable for its constituting the buoyant material of raft shipping. It is probable that cork and timber may be advantageously built into the ship in alternate layers, whereby a light compound mass, well bonded together, may be formed. The results shown in the following table will therefore be used.

<table>
<thead>
<tr>
<th>Compound materials</th>
<th>Proportional quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cork and wrought-iron</td>
<td>1 to '0077</td>
</tr>
<tr>
<td>teak</td>
<td>1 to '128</td>
</tr>
<tr>
<td>mahogany</td>
<td>1 to '128</td>
</tr>
<tr>
<td>elm</td>
<td>1 to '128</td>
</tr>
<tr>
<td>red pine</td>
<td>1 to '143</td>
</tr>
<tr>
<td>larch</td>
<td>1 to '187</td>
</tr>
<tr>
<td>yellow pine</td>
<td>1 to '187</td>
</tr>
<tr>
<td>white pine</td>
<td>1 to '283</td>
</tr>
<tr>
<td>poplar</td>
<td>1 to '386</td>
</tr>
</tbody>
</table>

It thus appears that a compound mass one-fourth the specific gravity of fresh water may be formed by combining

Hence we see in what proportions of thickness alternate layers of cork and other materials may be used to form the buoyant material of raft shipping, such that the average specific gravity of the mass shall be only one-fourth of the specific gravity of water; for example, a layer one inch thick of cork, or other material of the same specific gravity, may be alternated with 20 inch of iron, or 105 of oak, or 128 of teak, mahogany, or elm, or 143 of red pine, or 187 of larch, or 187 of yellow pine, or 283 of white pine, or 386 of poplar.

Hence it appears that if cork at 12 lb. per cubic foot, or other material of the same specific gravity as cork, be used for our buoyant material, every cubic yard of such material may, when built into the ship, be bonded together with 100 lb. of hoop-iron, producing a well-bounded mass of buoyant material, of which the specific gravity will be one-fourth that of water, and of which each cubic foot weighing 15625 lb will carry a load of 46575 lb.

It should now, from the foregoing tables, the great advantage of employing substances of light specific gravity as the buoyant material, it will become important to ascertain what substances or preparations of material will be available for the purpose referred to. There are many vegetable productions of tropical growth of a specific gravity nearly the same as that of cork, which productions may, like cork, be so prepared and manufactured as to form masses or blocks, of any definite size, convenient for being built in layers of definite thickness, into the hold of a vessel, and so chemically treated as to be uninflammable; such masses, manufactured by the aid of machinery, may be produced at probably a cheaper rate than cork, and be equally serviceable.

Moreover, for an example of manufacture, small boxes of suitable dimensions for being laid by hand, like bricks, may be formed of white pine, poplar, or other light wood, which would constitute a cellular mass of extremely light specific gravity, and which, if used in those parts of the ship least exposed to shot and shell, would be available for forming the buoyant medium of raft shipping. It is therefore suggested that if premiums be awarded for the discovery and production of buoyant materials, whether in their natural condition, or manufactured suitable for the purpose referred to, a choice of such material would be produced whereby dependence on any one kind would be obviated, and various materials fit for the purpose would be supplied at their fair market value, based on the cost of production. The specimen of buoyant material submitted herewith, six inches square and three inches thick, weighs 10 ounces, being at the rate of 10 lb. per cubic foot, or about one-sixth the specific gravity of water; consequently, we may calculate on the buoyant material for raft shipping being prepared and cemented in place at the average weight of 16-85 lb. per cubic foot, being one-fourth of the specific gravity of water. The buoyant power of such material will be 46575 lb. per cubic foot, exclusively of its own weight, and each ton weight of burden will require 47-8 cubic feet of such material, and the weight of the material itself will be at the rate of 14-9 cubic feet per ton weight per cubic foot.

Practical Construction.—We now proceed to explain the practical construction of raft shipping with reference to its buoyant properties, such being necessary to enable us to arrive at some definite conclusion as to the mercantile effectiveness of such vessels for carrying weight of cargo with reference to their size as expressed by displacement, and also to determine in the case of gunboats and ships of war, the definite weight that can be allowed for armour plating, with reference to the size or load displacement of the ship, whence the extent of armament and ammunition which the ship can carry may be deduced, for it is presumed that the guns and crew of such vessels should be fenced in by armour plating equal in thickness with their opponent. Protection from sinking is the object which we seek, and we require to know at what sacrifice of capability for carrying weight of cargo, in the case of merchantable ships, or of aggressive armament in the case of ships of war, that protection is to be obtained.
Having predetermined that the length of our ship shall be six times the breadth, and the depth one-third the breadth, and that the lines of the vessel shall be such that the displacement expressed in cubic feet shall be one-half the product of the length, breadth, and depth, we know from these data that, to obtain a displacement of about 2500 tons, the breadth must be about 45 feet, the length 270, and the depth 15 feet. These dimensions, under the above-mentioned conditions of construction, give the immersed hull a cubical content of 91,125 cubic feet, which, divided by 36, the number of cubic feet in a ton weight of fresh water, gives 2525, as the displacement of our ship in tons weight, and consequently the total aggregate weight of our hull, buoyant packing, packing for surplus buoyancy, engines, coals, ship's stores, armament, ammunition, and ammunition, such being the entire weight of the ship and its burden, and we propose to treat of each of these items separately.

1. The Hull.—For the sake of strength combined with lightness, we may suppose the shell and frame of the hull to be of steel, lined or plated inside with timber, and as the buoyant material with which the vessel is to be packed will greatly strengthen the shell of the vessel, we may assume the weight of the hull (including rig and equipment, but not including armament, armament, ammunition, or other stores) to be 25 per cent. of the load displacement, amounting in this case to 633 tons weight.

2. The Buoyant Packing.—This packing, on which the buoyancy of the ship is intended to depend, must be in such bulk, with reference to its specific gravity, that when floating in water, it will uphold from sinking the entire weight of the ship and its burden, consequently the bulk of the packing must be at least equal to the load displacement of the ship, being in this case 91,125 cubic feet, which quantity is represented as tinted pink on table 2, the specific gravity of this packing being one-fourth that of water, its weight will be one-fourth of the load displacement of the ship, or 633 tons weight.

3. Surplus Buoyancy.—We have hitherto made provision only for such quantity of buoyant packing as would merely float the ship, but in the case of ships of war portions of this packing may be blown away by the explosion of shells, which may have lodged in the body of the mass; it is, therefore, proposed to allow 20 per cent. surplus buoyancy, coloured light pink on the drawing, amounting to 18,225 cubic feet, the weight of which is 126 tons, the same being 5 per cent. of the displacement.

The centre of gravity of the hull and packing, amounting to 1392 tons weight, is shown on drawing.

4. Machinery.—It is proposed that this vessel of 2217 tons, builders' measurement, or 2531 tons displacement, be supplied with two 12-knot propellers, weighing 316 horse-power, working up to 1500 ind. horse power; the weight of the machinery complete and in working condition will be 316 tons weight, being 12 per cent. of the total displacement.

5. Coals.—One ton of coals per nominal H.P. will give about six days' supply at full steaming power, amounting to 316 tons, being 12 per cent. of the total displacement, and as the weight of the machinery and coals is necessary to the stability of the ship, it is desirable that the coals be stowed in the lower hold, and the coal-bunkers be fitted water-tight for the reception of water-ballast.

6, 7, and 8. Stores—Armour-Plating—Armament and Ammunition.—Having already appropriated, as above shown, no less than 80 per cent. of the load displacement, we have now left only 20 per cent. to amount to 507 tons weight, to meet the requirements of ship's stores, armour-plating, armament, and ammunition. The proportion in which these three items are to be distributed entirely depends on the intended armament for the ship, and the thickness of armour-plating which may be considered sufficient for the intended service. We may, however, assume the distribution as follows:

| Ship's stores | 2 per cent., amounting to 51 tons |
| Armour-plating | 12 per cent., amounting to 304 tons |

Armament and ammunition 6 per cent., 152 tons, of which the centre of gravity is shown on drawing, 507 tons. Hence the foregoing scale of appropriation of displacement gives as follows, viz.:

| Hull | 25 per cent., weighing 633 tons. |
| Packing | 25 | 633 |
| Surplus packing | 5 | 126 |
| Machinery | 124 | 316 |
| Coals | 24 | 58 |
| Ship's stores | 2 | 51 |
| Armour-plating | 12 | 304 |
| Armament & Ammunition | 6 | 152 |

Total | 100 | Diagp. 2531 |

From the above scale of appropriation of displacement the following table has been deduced, showing the weights available for armour-plating, armament and ammunition, the vessels varying from 257 tons displacement, to ships of 10,368 tons displacement, the largest size now built, whence we may see approximately what amount of armour-plating is available for ships of different sizes, and hence determine whether such vessels will carry out the object we may have in view. The weights shown as armour-plating, armament and ammunition in the following table, constitute the tons weight of cargo which would be carried by the ship if fitted for merchant service. (See p. 100).

From the foregoing table we arrive at the following deductions:

1st. With reference to armament-plating, it is manifest that in a ship of given size, as determined by displacement, the weight available for armament-plating is to a considerable extent a compromise with the weights required for machinery, coals and ammunition, as we increase the one we must reduce the other; but assuming the appropriations of displacement taken in the table, the rates allotted to armament-plating would give the following results:

<table>
<thead>
<tr>
<th>Thickness, if plated all round, 15 feet deep.</th>
<th>Thickness, if plated all round, 15 feet deep.</th>
<th>Thickness, if plated all round, 25 feet deep.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 9</td>
<td>2-42 inches</td>
<td>1-82 inches</td>
</tr>
<tr>
<td>10</td>
<td>2-75</td>
<td>2-06</td>
</tr>
<tr>
<td>11</td>
<td>3-10</td>
<td>2-33</td>
</tr>
<tr>
<td>12</td>
<td>3-50</td>
<td>2-62</td>
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<tr>
<td>13</td>
<td>3-93</td>
<td>2-95</td>
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<tr>
<td>14</td>
<td>4-31</td>
<td>3-33</td>
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<tr>
<td>15</td>
<td>4-73</td>
<td>3-55</td>
</tr>
<tr>
<td>16</td>
<td>5-21</td>
<td>3-81</td>
</tr>
<tr>
<td>17</td>
<td>5-69</td>
<td>4-27</td>
</tr>
<tr>
<td>18</td>
<td>6-20</td>
<td>4-65</td>
</tr>
</tbody>
</table>

It is also to be observed that if the length of the vessels be four times the breadth instead of three times, the thickness of the armour-plating in each case would be increased 50 per cent. on the above dimensions; and, moreover, if instead of platting the ships all around the armament-plating be confined to protecting the limbs of the ship, the thickness of the plating will be proportionately increased, the application of the weight available for armament-plating, armament, and ammunition is thus entirely a matter of arrangement dependent on the class of ship to be constructed.

It also appears that the ratio of power to displacement being given, and the vessels of similar type, the speed becomes greater as we increase the size of the ship. The extra cost that would be incurred in the construction of raft shipping may be approximately estimated as follows, supposing the material to be cork of the lowest quality, which is generally the lightest, and therefore the most suitable, for the purpose of raft ship packing. Take for example ship No. 9, of 2217 tons displacement:

- Cork for packing, 760 tons at £10  £7,600
- Preparation for rendering the packing unflammable, 760 tons at £2 10s. 1,900
- Workmanship and labour, preparing material, cementing, and setting in place, 760 tons at £2 10s. 1,900

Total  £11,400

Casualties 5 per cent.  570

Total for ship of 2531 tons displacement  £11,970

Being at the rate of about £5 per ton on the displacement tonnage of the ship.

Bear-Admiral E. P. Halden.—Mr. Atherton has so clearly and completely given his details and definitions, that the question is scarcely to be discussed, except upon its general principle. From
the paper just read it is clear that Mr. Atherton looks upon it as a question of absolute solidity. (Mr. Atheron: Yes.) This, of course, then becomes, with naval people, a question of accommodation, which does not seem to have been very comfortably provided for. However, there may be circumstances wherein vessels of that sort may be constructed for special purposes, perhaps with greater changes or far greater changes have actually introduced themselves within the last ten or fifteen years even than the one noted above.

**Mr. Alexander Gordon:**—With regard to the question of inflammability, I am satisfied that Mr. Atherton is entirely correct. I have had great experience in the preparation of timber for lighthouse and other works, where the danger of fire was considerable, and I found that by Mr. Maughan's process, which was patented many years ago, timber was rendered inflammable. You may put a piece of wood so prepared into a furnace and you may bring it out red hot, but it will not carry fire—it is inflammable. I mention this after having had great experience with timber prepared by Maughan and others, that this process is not more generally known. In a conversation with Sir George Cockburn, when he was at the Admiralty, I proposed the subject of preparing the ceiling and internal fittings of H.M.S. "Simoom." It was also proposed to line the ship with kalmpinkino so prepared, of which I produced some specimens perfectly inflammable.

**Captain Julius Roberts, Royal Marine Artillery:**—I believe Mr. Atherton has in his mind the idea of connecting the sides of the ship together by bulkheads, forming cellular compartments, right through, so that each of these compartments, separately formed with thin sheet-iron, adds very little to the weight of the cork. This would form a great protection against the penetration of shot, and those cellular spaces filled with packing would give the ship a vast amount of strength in every way.

**Captain Selwyn, R.N.:**—We must recollect that the use of rams is dependent entirely upon their possession of extreme speed, superlative speed, I may say, and the most perfect power of manouvring. Unless these two conditions are attained, the use of rams is one which may possibly sometimes be brought into play against other vessels which are at anchor, but which can never be brought into play in those great naval actions which should take place, as they have always done, at least with the English, on the open ocean, where the question is, how to chase your enemy, how to catch him, and when caught, how to dispose of him. The ram will play its part indubitably; but we must not rely any more exclusively on that than we must on guns, or on the peculiarities of ships, which may be attained, as Mr. Atherton has very properly remarked, by a compromise which sacrifices in a certain degree each one to all the others, that is to say, the speed may be attained by a certain sacrifice of capacity, and of seaworthy qualities. The enormous power of carrying fuel may be attained by other sacrifices; and so we may go through the whole list of complications, never being able to attain in absolute perfection the whole of the objects which we seek.

With regard to penetration, and how it is to be resisted, Mr. Atherton, I think, does not intend that the cork or other buoyant material which he employs as packing should be viewed in any measure as a resistant material. He relies for that on the armour-plate outside, and which must remain very much as it is at present, a question between the power of the gun and the power of the armour-plate. If we build our ships of a lighter material, such as steel, we may then afford to devote increased thickness to the armour-plate, and, therefore, be able to resist heavier guns than those which are now brought against us. If, on the other hand, our enemies find that we are so disposing our weights, it is reasonable to expect that they will increase the power of their ordnance up to the power of which they may be effective against the increased resistance. The cheapest buoyant material we have, and that hitherto has been resorted to, is air,—cellular spaces filled with air; and the only objection which I understand Mr. Atherton entertains to that, is the possibility of penetration in every line by shot or by shell. Now, I think if we were to enter into a calculation of the thickness of the transverse partitions required to stop shot after they have penetrated a portion of the water (because they are not dangerous above the water-line), but passing through a portion of the water, the armour-plate, and then a certain number of the cells, if that thickness of armour-plate and of armour-partition were calculated, we should find it rather inferior to the weight of the packing which would be required to prevent the ship becoming water-logged from these transverse perforations. There is another circumstance to which we may turn our attention usefully—that having engines on board, we can use them to pump air into the air-cells to keep out the water; and then, however pearlless the cells may remain—air-cells filled by a material which, after all, if perforated, does not keep out water. In proportion as the cells, whether the packing material be cork or light porous wood, are destroyed by the impact of shot, so will the water penetrate those cells, and enter among the splinters or the powder into which the material would then be reduced.
thus not giving us the full value which we should obtain, if we considered it only as cork having certain buoyant qualities. When by penetration in whatever direction the ship has been reduced to the water-logged line, it is very clear, he says, that the engine might be drowned out, and the ship would certainly be drowned down to such a line of flotation that her manoeuvring power would be destroyed, and that any ship that ran against her having superior manoeuvring power. I do not urge this as an objection, but I merely urge it as a remark as to what would be the result in such a case of water-log. When you have also a large quantity of buoyant matter, if there be an alteration in the centre of gravity, you find, if you will put that in this ship carrying a barge, carrying masts and yards, you will so seriously compromise the centre of gravity, that you are liable to have your ship capsize, although she floats, particularly if she is in a sea. If it be possible, as Mr. Arthur seems to show, that we may have ships that will not sink, then it becomes a very grave question whether the cupola may not be more efficiently introduced than they have hitherto been, for the whole secret of the want of success of the cupola system in large ships seems to be, that it is necessary to defend the ship as well as the gun. Not alone must you put armour round the cupola, but you must put iron round the ship, not only to prevent her being hit, but to prevent her offensive power mortaring in the ship, being injured and sunk. If it is possible to make a raft like that, we shall return to that ingenious invention, for which Captain Cowper Coles deserves the greatest credit, of putting heavy guns on an unsinkable raft. I hope, by the devotion of such talent as that of Captains Coles and Babbage, the Naval Officer, and as that of Mr. Atherton as an Engineer, to the subject of the present system is not yet at rest, as there is still to be a more clear conclusion than we have hitherto been able to do.

Mr. Atherton.—The stores and ammunition will be stored in water-tight cells formed in the packing, so that in the case of the ship being sunk to the water-logged line all the stores and ammunition would be safe. The arrangements for the accommodation of the crew would be dependent on the number of the crew and position of the batteries. I do not pretend to know how a ship's batteries ought to be arranged, whether broadside, cupola, or fore and aft, but I have assumed that in this case the batteries would be fore and aft, thereby affording the necessary amount of accommodation for the crew and the ships between decks. The lower hold I mean to be exclusively appropriated to machinery and coal. The coal will be put into water-tight compartments, and the coal as consumed the bunkers may, if necessary, be filled up with water, to preserve the stability of the ship. As regards present mortar practice, we now have present batteries, and I think that at any rate it is not at all comparable to what I anticipate being resorted to as the agent for sinking iron-clad ships, viz., masses of eight or ten tons weight being thrown nearly vertically to a considerable height, and falling into a ship through the deck at a range of say 200 yards only. As you shorten your range you arrive at greater precision, and doubtless mortar practice may be so modified that at short range, say 200 or 300 yards, you would not fail to drop a shot or shell through the deck of such a vessel as the "Warrior." With regard to the efficiency or otherwise of rams, it is not for me to discuss that question. I am of opinion they may become formidable rivals to ships of war as now constructed, and, therefore, I agree, and then she would be the ship of the age, though assailed by the ram. With regard to penetration, the theory I go upon is that nothing will stop the penetration by shot. I anticipate that the penetration will be absolute, but whilst the packing remains an integral part of the ship it will float on the ship. You must entirely get rid of overboard that 172 tons of surplus packing before the ship will displace water. As regards air-tight cells, if of iron, they would probably be of equal weight, and occupy the same space as the packing. I believe it would be very difficult to make the cellular system absolutely air-tight, and if perforated by shot they would become less effective. By the proposed system when the vessel becomes perforated we have calculated that we still have the ship's deck some two or three feet above the water-logged line of flotation; therefore, I do not see why that ship, though water-logged, should not be perfectly manageable and seaworthy. Many a ship goes to sea with a water-line as low as that. The stability increases as she gets down, because the centre of gravity becomes lower with reference to the centre of displacement.
privilege of using their collections. Now, at this time of final divorce, nothing could be more friendly than the terms upon which they stood towards each other. Speaking ministerially, the question was not whether they had been considering confidentially, they had very little ideas where they would go. But they were working hard for a place, and he might say, without breaking confidence, that their condition was under mature consideration by a very important body, of a cognate character to their own, though somewhat older, and more dig- nified— the Royal Institute of British Architects.

He now passed to the special work which they had to perform that evening, namely, the distribution of prizes. The meeting were aware that last year was a year of disappointment. They offered valuable prizes, but it was not considered that the competitors came up to the mark, and they went down to South Kensington with dear faces and blank cheques. This year they adopted the course, not of sulking or despairing, but of revising their list of prize objects, and offering prizes even more valuable in a monetary view. He was glad to say that the exhibition of one class of works of art had met with signal success. They had had an unusual good tender of objects, and they felt that they might conscientiously award the large prizes which they offered to the competitors. He was exceedingly glad to have to say that the art-workmen of the country had awoke to the movement of the times—he did not allude to the Reform movement. He was glad to say that they felt in all things the growth of education and of refinement: that growth of refinement which had substituted the plainness for the panache, and the dignity of composition for the elaboration of years ago—a cheap press which had placed the study of literature and the discussion of political questions, whether they agreed with the conclusions they were come to or not, on the high level which they now occupied. He was glad to see the realization of the growth of education and the improvements that had taken place in those means of locomotion that made the word "provincial" almost a word belonging to the dead languages. The growth of science had extended itself to the wants of private life, and people felt that the furniture they lived amongst, the carpet they trod upon, the arm-chairs they slept in, the plates from which we eat, the motion and the musings in which we wash, their faces, might be, need be, should be, and could be, specimens of art, without being too expensive to those persons who might become their purchasers. He was glad our workmen realized that fact, and this brought him to another point. The other day a capitalist, who was a producer of art-workmanship, had asked him whether Mr. (Mr. Hope) knew what he was about: whether he knew the necessity of capital to produce these large works, and was he not putting the art-workman out of his place? He (Mr. Hope) said distinctly he was not putting the art-workman out of his place; and he would tell them why. Everybody's duty was to be moving on. It was like the theory of the economist, and all the fixed states in reality revolving round some very distant central sun. He did not put the art-workman out of his place, because the capitalist who employed that workman, and the purchaser who went to the capitalist, had themselves marched on, and he only asked that the art-workmen should march on by their side. Of course, there were many branches of art-workmanship that required capital to put them in the market, and he should be a very bad friend to the art-workman if he were to come forward to bring down that necessary law of political economy which made the capitalist necessary to put his work in the market,—ay, and necessary to give him the materials with which he could work. All he maintained was that the workman should go on, but he did not destroy the relations between the employer and the workman. It only placed them in a more satisfactory position towards each other. He showed the workman that artistic work was wanted from him; and it told the employer that it was right and generous that with his name the name of the man who did the work would be known. Of course, many art-workmen would only be art-workmen all their lives. It was an honourable thing to be an art-workman all one's life if one stamped his name on the work. But it was possible that, like Chantrey, a man from being an art-workman might become a great master and teacher of art, and he was for showing the door open to such a man, that he might come forward and prove himself a Chantrey. He would give an illustration in point. It might be thought a trivial consideration, but it would show his meaning. For many years past it had been the habit in this country to hold flower shows, at which they saw that Mr. Smith, gardener to Lord Brown, took prizes. Lord Brown was the capitalist, but Mr. Smith's knowledge of botany produced the grapes, the melons, or the roses which won the prizes. Now, he wanted the art-capitalist to be the squire, and the art-workman the gardener.

Wood Carving.—Prize, £1,000.—Arthur H. Harris, Ryde, Isle of Wight; prize, £2, £5.—John Seymour, Tower-lane, Taunton; prize, £3, £5.—Henry Harrison, 82, Upper Ebury-street, London; extra prize, £1, £1.—T. Sharp, 50, Connaught-terrace, Edgware-road.

Stone Carving.—Prize, £20.—Arthur N. Harris, Ryde, Isle of Wight; prize, £2, £5.—John Seymour, Tower-lane, Taunton; prize, £3, £5.—Henry Harrison, 82, Upper Ebury-street, London; extra prize, £1, £1.—T. Sharp, 50, Connaught-terrace, Edgware-road.

A Supplementary prize, £10.—W. Wormleigh, at Mr. Roddick's, 10, St. James's-street, Birmingham.

Silver Work.—Prize, £1, £1.—W. Hollliday, 14, Nailour-street, Islington; prize, £2, £5.—A. G. Frantzen, 20, King-square, Clerkenwell.

Transparent Enamels.—Prize, £1, £1.—Frederick Lowe, 13, Wilderness-row, London; extra prize, £1, £1.—H. D. Kening, 59, Dean-street, Soho.

Opaque Enamels.—Prize, £10.—Frederick Lowe, 13, Wilderness-row, London.

Wood Mosaic.—Prize, £10.—George Cooke, 27, Bywater-street, King's-road, Chelsea.


ON ARCHED ROOFS.*

By C. R. Von WESSELY.

The present paper does not aspire to exhaust the very interesting subject of arched roofs as it stands at present before the profession. Its purpose is only to describe some structures of this kind recently carried out with success, and to make a few comparative remarks upon their main features and merits. In offering the same to this society it is the hope of the author to elicit valuable criticism from different quarters, and by a discussion of a subject on the theory and practice of which very little has been published hitherto, to throw more light upon the many important questions connected therewith. It is a desideratum universally felt in the engineering profession, to have as complete as possible a collection of the designs and details of important engineering structures; a contribution towards such a collection, however incomplete, may not be thought out of place before a society entirely devoted to the advancement of engineering science.

Arched roofs are the production of the conjoint requirements of beauty and strength. So long as the roof is destined to serve as a mere object of utility, an engineer would spend very little trouble in designing fine outlines and selecting noble proportions. Economy of material and workmanship dictate such plainness of design, that, firstly, the engineer shall be able to take out the strains so minutely as to reduce the sectional area to a minimum; and secondly, that the roof is carried by itself and does not induce any transverse strains in the structure supporting it.

* Read before the Society of Engineers.
The usual triangular principle is adopted in such cases. It is a very different matter when a roof is to be made for an architectural building, for instance a large hall, where it is often the main feature of the structure. Fine outlines and simplicity, two main components of noble appearance, will be required most particularly. No obstruction to the view, as tights, struts, etc., are admissible. Architecture having been always represented in stone, forces its newly acquired material, iron, into the customary shape of the pure arch. A more or less powerful horizontal thrust has now to be provided for, and a certain deficiency in the practicability of minute calculation of strains under unequal loads must be compensated for by the sound judgment of the engineer. Many different arrangements can be embodied in the structure supporting arched roofs, for taking the horizontal thrust, but no rules can be given for it. In each separate instance the arrangement must be adapted to the peculiar nature of the case, and depend on its degree of perfection entirely upon the skilful design of the engineer. A few words on scientific investigations with regard to wrought-iron arched ribs, may not be out of place, before beginning the description itself.

The calculation of strains in arched roofs is one of the most difficult mathematical problems in engineering, partly on account of somewhat complicated principles on which a thorough investigation should be founded, partly on account of a great variety in the position of the different parts of the structure. Unfortunately there is very little information on this subject to be found in English engineering literature, and not much more in that of other nations. The following is submitted as a means of approaching the subject of wrought-iron arched ribs.

It is well known that the way of ascertaining the stability of a stone arch is to draw the curve of equilibrium, which must remain within the depth of the voussoirs of the arch. This is not necessary in the case of iron-arched ribs, which can be strained by tension as well as compression.

The outer forces which act upon an arch are, 1, its own weight; 2, the vertical; 3, the horizontal pressure due to the resistance of the abutments; the latter is transmitted unaltered through the whole of the arch, since there is no other horizontal strain acting upon it but that of the abutments; 4, the pressure of wind and snow.

In every arch there must be somewhere one particular point in which this horizontal strain is not co-existing with any vertical force; therefore, if we cut the arch through this point in two pieces, in either of them the state of equilibrium will be conserved, by replacing the action of the other by that horizontal strain. This point is coincident with the point of action for the result of the vertical force for the whole arch. Thus, in an arch under its permanent load, the section before mentioned will be at the crown; in an arch under both its permanent and unequal loads, it cannot lie in its crown. The curve of equilibrium passes through the section with its vertex.

The way to find the horizontal strain is as follows: Given a section of the arch, the distances from the left-hand springing are \( x_1, x_2, \ldots, x_m \) with weights \( p_1, p_2, \ldots, p_m \) accordingly, and \( x \) on the distance of the vertical section before mentioned, we find

\[
p_1 x_1 + p_2 x_2 + \cdots + p_m x_m = \sum x_1 p_x = H_y
\]

where \( H \) is the horizontal strain, and \( y \) the rise of the curve of equilibrium.

This equation (\( \sum x p = H_y \)) does not determine \( H \) or \( y \), but assuming one of them it ascertains the other.

By taking \( y = \frac{H}{x} \) (the height of the neutral fibre in section \( m \)) the vertex of the curve is drawn through point \( C \) (Figs. 1, 2, 3, Plate 14); \( H \) is thus determined, and section \( m \) is in compression according to \( H \).

It is quite clear that not all the other points of the curve will in this case fall within the neutral fibre of the arch, but will take the position as shown by the dotted line, though it must go through the supports. This causes a tendency for point \( B \) to move in the direction of the arrow; and strains in the flanges at that place will be effected accordingly.

If the rib in \( B \) would really not be strong enough to withstand this strain, there is no necessity yet that they should break, but the case will be as follows:—

\( y' = y \) is assumed so that the curve of equilibrium passes through \( B \), and renders this point to be simply in compression.

\( H \) is determined by the equation:

\[
H = \sum p_x y
\]

and acts on a lever \( y' = y \); or in regard to section \( m \) on a lever \( y_1 = y \), and will effect a compression in the upper flange and a tension in the lower one at this place. Thus the fact that the section at \( B \) is in mere compression is conditional, and depends entirely on the presence of sufficient rigidity of the flanges at section \( m \). In respect to these considerations, it is certain that stability and rigidity of an iron arched rib can be fulfilled by different arrangements.

Although it appears strange at first sight that in an arch, of which the architectural outlines are given, there should be no restrictions in assuming the position of the abutments and the line of the flanges at section \( m \). In respect to these considerations, it is certain that stability and rigidity of an iron arched rib can be fulfilled by different arrangements.

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Given an elliptical arch, in which the different areas in flanges, etc., have to be determined. The distance of the points where the load acts, and the loads, are determined. Thus the equation \( sp = H_y \) can be formed, by which it can be seen that \( H_y \), the horizontal strain, might be taken ad libitum, and that \( y \) will then be ascertained according to the equation. For instance, \( y \) may be taken equal to a, which is greater than the rise of the arch, the vertex of the curve will be in \( C \), and its branches will go through the points of support, as shown in sketch.

\( H \) is determined by putting \( a \) for \( y \) in the equation. The position of this curve leads to the remark, that in the crown, besides the horizontal strain \( H_y \), which is transmitted through the structure and taken by the abutments, there will be a certain tension in the lower, and a compression in the upper flange, due to \( H_y \) acting on the level \( CC \); and that, following the line of the curve from \( C \) towards \( A \) or \( A \), there is a point \( B \), or \( B \) on each side, where the curve of equilibrium intersects the neutral fibre of the arch, and where only compression exists.

The segment between \( B \) and \( B \), therefore acts as a girder, while the joints at these points could safely be replaced by hinges as long as the load is equally distributed. The abutments will, in this case, react with a horizontal strain equal to \( H_y \).

Now, instead of the abutments, a tie may be supposed between \( A \) and \( A \), and a screw in it, to effect any required horizontal strain on these points, and it may be arranged so that this horizontal strain is \( H_y \). By putting this \( H_y \) into the equation, the calculation gives \( y = a \), which is smaller than the rise of the arch. \( A \), \( A \), \( A \), \( A \) is not the curve of equilibrium.

The horizontal strain \( H_y \) is transmitted through the crown unaltered, but, besides this, there exists at the crown tension in the upper and compression in the lower flange, due to \( H_y \) and the lever \( CC \), on which it acts. According to the curve assumed in this case, the whole of the arch will act as a girder under forces acting on it, and the horizontal strain of the flanges and diagonals have to be determined accordingly.

No doubt, by means of the supposed screw, a horizontal strain, \( H_y \), can be applied to the arch, so that the corresponding \( y \) becomes equal to the rise of the arch \( a \), in which the entire section at the crown is in compression due to the force \( H \). In other words, by means of a tie and a screw in it, the curve of equilibrium can be forced to pass through the crown, or through any other point in the vertical \( C \) \( C \), and if the material is distributed in the structure according to a certain curve of equilibrium, it will enable the abutments to bear the horizontal strain belonging to this curve.

On the other hand, this does not require that a wrought-iron arched rib of a certain shape must have abutments of a certain strength, there being even a chance for the stability of an arch without any abutment or tie. The only consequence of this is that the rise of the curve of equilibrium becomes \( 0 \), and the horizontal strain by the curve of the flanges at \( A \) and \( B \).

The crown of the arch will, therefore be strained as if it were the centre of a straight girder of the length \( AA \). Now the question arises, which curve of equilibrium, among so many which do not exclude a chance of constructing the arch, will be that one according to which the least quantity of material is required?

Although the solution of this question with mathematical accuracy is a matter of almost impracticable complexity, the following consideration leads to a sufficiently practicable result:
namely, it can be proved by simple calculation and by many instances of practical engineering, that a certain load distributed over a given space can be supported in a more profitable way by an arch in which only compression prevails, and which rests between abutments, than by a straight girdler. Therefore it is more profitable to arrange the material in a structure so that it is strained in the same direction as the compression and tension co-existing in every part of the structure.

From this truth a rule can be derived to lay the curve of equilibrium so that its points may be as close as possible to those of the neutral fibre.

The calculation of strains in the different parts of the structure (flanges and diagonals), can be dealt with by starting at the intersection of the curve of equilibrium with the neutral fibre, where the strain is known from the curve and continuing by proper combination of this strain with the vertical loads.

SYDENHAM CRYSTAL PALACE ROOF.

There are two roofs of similar construction, but different span. The principals are, in both roofs, arranged in pairs, being 24 feet apart in each pair, but the pairs leaving a clear space of 22 feet between them. The 120 feet span roof is to be described first, the alterations of dimensions in the 72 feet one to be given afterwards, details being quite alike in regard to their general arrangement.

The principal of this roof is very peculiar in its construction. It is an arch of such a depth that it carries partly as a girdler, throwing upon its supporting structure a comparatively small horizontal load. To this the girdler is 10 foot high. To the top of the arch is a perfect semicircle, struck from the same centre, the rib has therefore throughout an equal depth of 8 feet—the inner radius being 53 feet, the outer one 60 feet. The rib consists of a bottom and top flange, each consisting again of two L irons, 6 inches by 31 inches, and a ½ inch plate 10 inches wide having an available sectional area of 19 square inches. The flange fits in the length of the rib of equal cross section, and are connected together by a double lattice-work made of flat diagonal bars. Each side of the rib is divided into eleven equal parts, between its sprigging and its centre. Each of these parts contains two diagonals one above the other, and struts radiating to the centre; one of the struts being a cast-iron distance strut carrying purliins and connecting them to main rib. The other is a wrought-iron strut made of two channel irons 4 inches by ½ inch, having two distance pieces riveted between them. The joints in 6 inches by 3 inches L irons are made alternately at intervals of about fourteen feet, proper distance pieces filling out the 2½ inch space between irons, leaving no piece only at single bearing area. At intervals of about 1 ft. 9 in., distance pieces are put between L irons, and fixed also by ½ inch rivets as in W I struts. The diagonal bars are throughout 4 inches wide, ½ inch thick with an available sectional area of 12 square inches running always through two diagonals, and are not straight, as they are in structural appearance, so arranged that they cross exactly in the middle of the rib, and in one fourth of its depth from its outer and inner outline. They are connected at intersections by a 1 inch rivet. A round ornamental knob, made in two halves, being connected together by three ½ inch tap bolts, covers this joint. The ends of diagonals and W I struts are connected with the L irons by a 1½ inch bolt.

The cast-iron distance struts are shaped according to the W I structure, which they have to strengthen, and according to the castiron end pieces of purliins, which are bolted to them by six or four ½ inch bolts, as they belong to the 6 feet or 3 feet deep purliins. The struts have a length of 7 feet 6 inches of square inches sectional area, its 3 inch web is widened out to a pocket for letting the diagonals through, intersecting at this point. The web at top and bottom of strut is brought out to two legs, which fit with a washer between the two angle-irons, and are each bolted to same by one ½ inch bolt. Proper bosses are cast on to the web at top and bottom, and to the 2½ inch plate. Underneath these struts, ornamental pendants of 5½ inch metal, are bolted to sofist of rib by four ½ inch bolts. There are two kinds of purliins, one kind being 24 feet long and 6 feet deep, and the other 72 feet long and 3 feet deep. The first serve for bracing each two ribs of one pair together, the others act as pure purliins between each pair of ribs, that is, they have the only distinction to support the intermediate rafters.

The 6 feet deep purliins consist of a top and bottom flange of two L irons, 3 inches by 2 inches by ½ inch of 3 square inches available sectional area, they are connected by wrought-iron struts and double lattice work. Besides carrying intermediate rafters, they serve as bracing of main ribs for giving them lateral stiffness. The struts are 8 feet apart, and consist of two T irons, 2 inches by 2 inches by ½ inch, with 1½ inch available available sectional area, having a cross section of 7 square inches, the struts are, other, similar to the lattice work in main rib. The diagonals are flat bars, 3 inches wide, 5½-inch thick; they are straight, and run always through two divisions of 8 feet. At their ends proper distance struts are fastened to L irons by one ½ inch bolt. The web is again widened out properly to a pocket for receiving ends of two diagonals, and the rivet is fastened to casting by one ½ inch rivet. The 3 feet deep purliins serve only for carrying the intermediate ribs. They consist of a top flange of two L irons, 4 inches by 2 inches by ½ inch, 3½ available square sectional area in centre, and a bottom flange of two flat bars being at end, 4½ inches by ½ inch in centre, 3½ inches by ½ inch, with 4½ square inches available sectional area. These flanges are connected by vertical struts 8 feet apart, and diagonal tie bars, decreasing in the three diagonals next to end from 11½-inch thickness to ½ inch, to 5½-inch thickness to ½ inch. They are respectively fixed to top and bottom flanges by a ½ inch, 1½ inch, 2½ inch, 3½ inch, and 4½ inch bolts. They are made of cast-iron and a X cross section, 2 inches by ½ inch; diagonals of wood are put across the diagonal tie bars, 4 inches wide, ½ inch thick, fastened by ½ inch bolts. Both purliins carry above each strut an intermediate rafter, having the same outline as the main rib. It is made of a ½ inch wide flat bar, 10 inch high, in the first division, a top and bottom flange of two L irons 2 inch by 2 inch by ½ inch in length, of about 16 feet. 10 in. with 1½ square inch available sectional area. A special arrangement is made for bracing purliins to these intermediate ribs. The purliins at each end of their vertical struts are suspended, as it were, by two hanging rods, to points of the intermediate ribs, being just in the middle of the two bearings or purliins. For that purpose, a cast-iron shoe is fixed to the bottom L irons of rafters at those points, by four ½ inch bolts of a proper shape, to fix on it the ends of the hanging rods, ½ inch in diameter, by keys. The other ends are widened out to an eye fixed to the bottom flanges of the 6 feet of 3 feet purliins by the bolts fixing end of the vertical strut to the same. The details of this connection are for both purliins the same, except the altered angle of the hanging rods. Next to each of the cast-iron end struts of purliins a kind of pocket is rivetted on by eight ½ inch rivets, consisting of two ½ inch plates, with two ½ inch thick distance pieces between them, riveted to the same by ½ inch bolts and to the eyes, and fixed by one ½ inch bolt each. The wind ties are, throughout, round rods of 1½ inch diameter, and form the diagonal bracing between main ribs. At the point where they cross each other they are connected by a ring, to which each end of the four is screwed in the usual way. The ring is in this case of cast iron. The ventilating section is made of 2½ square inches, strengthened by proper bosses round bolt holes, and besides by two wrought-iron rings of 1 inch sectional area, put on while hot red. This connection serves for bringing strain on to these diagonal bracing rods.

The covering of this roof is entirely of glass, on the "ridge and furrow" principle. The main and intermediate ribs carry wrought-iron gutters, 9 inches wide at the top, 7 inches at bottom, 4 inches deep. They are rivetted to L irons of ribs by ½ inch bolts, about 9 inches apart alternately, and to intermediate main ribs by ½ inch bolts in the same way. To the edge of this gutter an L iron 1½ inch by 1½ inch by ½ inch, is rivetted on, and to this a piece of wood 1½ inch by 2½ inches is fixed by ½ inch screws, about 6 inches apart. Into this piece of wood the ends of the sash bars are let in about 1 foot apart; the top being fixed to the ridge. This miniature roof runs right along the whole rib, from the main gutter up to the middle of the top layer of rafters. The main ribs, as well as intermediate ones, carry at their crown, over the cast-iron distance strut next to centre, a louvre standard of cast-iron, 5 ft. 10½ in. high, of H cross section. The sides are filled in with wood, to which the louvre plates are fixed.

The ventilator is covered, as the other parts of roof, by a number of similar small hipped roofs, formed by mere slanting sash bars, having in this case only wooden gutters, each
supported by the standard in centre of each rib. The outer
standards of ventilator are kept up by a diagonal bracing running
from each to the other, consisting of \( \frac{1}{2} \) inch round rods,
passing through holes, being fixed thereunder to reach the
ribs. At the base of outer standards a wrought-iron gutter runs
along, supported by wood boarding, for conducting the water
which drops down from the ventilator covering to gutters on
top ribs. The main rib weighs 10 tons. The purliins which are
6 feet deep, weigh each 12 cwt.; those 3 feet deep weigh
each 8 cwt. Each of these is supported by two columns, 8 feet
apart, so that each of the flanges starts over one of the columns. This is effected by means of a cast-
iron square frame, 8 ft. 8 in. wide, and 8 feet high, bolted to
the top of each column by four 1 inch bolts, and also by four
1 inch slotted holes being fixed thereunder to afford an
opening of \( \frac{1}{2} \) inch for gutters connecting top of columns. It
consists of two pieces of the same section as the columns,
connected by a \( \frac{1}{2} \) inch web with a large circular hole taken
in the middle and smaller ones in the corners. Proper flanges
are cast on to the top corners of it, to which each of the flanges
is bolted on by six \( \frac{1}{2} \) inch bolts, by means of a strong bracket.
The cross sections of this frame, through the weakest part of
the columns, has 233 square sectional area—columns being of
8 inches outer diameter, octagon 1 inch thick, the web and its
flanges \( \frac{1}{2} \) inch thick. The parts of frame acting as bracing to
the angles has 9 inches sectional area. Appropriate pockets for
receiving of diagonals are spaced out in the middle of the web, the outline of which is shaped like that of cast-iron
distance struts. The two diagonals in the middle are fixed to
it by one \( \frac{1}{2} \) inch bolt, and the diagonals at springing of flanges by one 1 inch bolt each. On top of outer column of
frame gussets are provided for fixing brackets of \( \frac{1}{2} \) inch inner
water outlets of main gutter by four 3 inch bolts with 1 ft. 2 in.
by 5 inch waterway. The main gutter running along the whole roof is, on the average, 1 ft. 9 in. wide and
11 inches high. It is cast in lengths of 7 ft. 11\( \frac{1}{2} \) in., 7-16ths of
an inch thick, the joints being made by eleven \( \frac{1}{2} \) inch bolts.
The intermediate ribs are supported by cast-iron standards 8 feet high by various lengths of 6 feet, 3 feet, deep and 23 ft. 3\( \frac{3}{4} \) in. long, which serve in the whole building as bracing and floor-carrying girders between columns 24 feet
apart. Such girders brace the columns also right under the flanges
of main rib lengths. The before mentioned standards have
the section of half a column of 7 inches diameter, are of \( \frac{1}{2} \) inch metal, and are connected on the top to a bracket, on which
base of intermediate rib is bolted by six \( \frac{1}{2} \) inch bolts. The lowest
of purliins connected to top of frame supporting main rib is also
connected by four \( \frac{1}{2} \) inch bolts to this bracket, and proper purliins are
cast on to the top of standard for fixing a bracket, by four
\( \frac{1}{2} \) inch bolts supporting main gutter at each 8 feet. The horizontal
trusses of the main ribs are trussed by 3-1-2s of an inch, the rivets of the system of columns connected by cast-iron girders as described
before, and well braced by diagonals fixed to ends of girders by
means of keys.
At the intersection of vertical diagonals a similar adjusting
connection with a ring and screws, as for wind ties, is applied, the
whole being covered by an ornamental joint cover. The entire
supporting structure up to the frame being very rigid, and
besides loaded heavily by having on the girders below floor level
on one side a fire-proof flooring of brick arches, and on the other
side cast-iron girders fastened to brick foundations, takes easily
the wind loading without much from wind pressure than from wind load
of the roof, which is only taken partly by the ridge of the being of so great a depth. The rain water is carried off in the
usual style by the hollow columns.
The smaller roof is very similar to the larger one, as already
stated; the dimensions of the details being altered only. The
principal ribs, in particular, have at 72 feet distance,
having a clear space of 72 feet between. The rib of principal
has an equal depth throughout of 8 feet, the outer and inner outline
of it being struck from the same centre respectively, with a
radius of 36 feet and 26 feet, its curve is a true semicircle. The
top and bottom flanges are connected by flat bar diagonals,
whereas the main ribs are connected by flat bars, consisting of two
4 inch by 4 inch, having an available sectional area of
636 inches. The diagonals are throughout flat bars, 4 inches wide
by \( \frac{3}{4} \) inch, having an available sectional area of 1 inch. The
vertical wrought-iron struts are channel iron, 4 inches by 1\( \frac{1}{2} \) inch, with available sectional area of 1\( \frac{1}{2} \) inch. Each
of these struts and diagonals are connected by one 1 inch bolts to
the flanges, L-iron being jointed in lengths of about 25 feet alter-
nately. The arrangement of lattice work is the same as in large
roof, and with\( \frac{1}{2} \) inch bolts being fixed thereunder to reach the
ribs in the same way. There are also two kinds of purliins, 6 feet deep;
nearly 24 feet long, and 3 feet deep, others near 72 feet long. The
construction and dimensions of them are like those in large roof. The intermediate ribs are of the same construction and dimen-
sions as on large roof; so is the arrangement of gutters fixed on each 8 feet apart, and the arrangement of struts, bracing and wind ties is also similar to that of large roof; the ventilator is also the same. The main rib weighs 49 tons; one purliin, 6 feet deep, weighs 12 cwt.; one purliin, 3 feet deep, weighs 1 ton 4 cwt.
Iron work of roof only in one bay of 96 feet, that is from
centre of one pair of main ribs to the centre of another pair of
them, weighs 50 tons.
The main rib is supported by structure similar to that of
the large roof, that is by a frame formed by two shorter pieces of
columns connected by a web. To the outer one is the main
purliin fixed of same dimensions as on large roof. The intermediate
are also like those of large roof, and supports all the details of
connections being the same. The 72 feet trussed purlins used in
these roofs are the same trusses that were used for carrying the
roof over the nave of the Great Exhibition of 1851. A large
portion of the columns and girders, also employed in the Syden-
ham Crystal Palace, are the same as were used in the Great
Exhibition building.

**Main Arched Roof of the Dublin Exhibition Palace and Winter Garden.**

The area devoted to the portion of the exhibition covered by
this roof is 21 feet 10 in. by 50 feet 6 in. The space occupied by
the Winter Garden, which is covered by a similar kind of roof, is
353 feet 6 in. by 30 feet 6 in., having a transept 33 feet 8 in. wide and
50 feet 6 in. long. These two areas are divided respectively into
thirteen and twenty-one bays of 16 feet 10 in. It is proposed to
cover the roofs of the principal rooms, comprising the purlins, purliins, and covering, and the supporting structure, with the arrangements for taking the horizontal thrust.
The outline of the arched rib principal is semicircular, the radius
of the intrados being 20 ft. 6 in., and the extrados 28 ft. 14 in.
The rib is thus about 1 ft. 1 in. thick, and at its springing 2 ft. 8 in.
depth. It consists of a bottom and top flange each of two
L-irons 24 in. by 24 in. by \( \frac{1}{4} \) inch throughout its length, connected
together by diagonal bars. The four diagonals next to the crown
of the rib are 24 in. by \( \frac{1}{4} \) inch, the next three are 22 in. by
\( \frac{1}{4} \) inch, then follow three of 3 inch by \( \frac{1}{4} \) inch, and the other three are 3 inch by \( \frac{1}{4} \) inch, the rivets for connecting the
diagonals to the flanges being \( \frac{1}{4} \) inch, \( \frac{1}{4} \) inch, and 1 inch diameter,
according to the strength of the diagonals. At their intersections
the diagonals are connected by \( \frac{1}{2} \) inch rivets. At each point
where the dimensions of the diagonals vary the purliins are
fixed. There are therefore three purliins on each side exclusive of the
ridge purliin at the top. The purliins are of cast-iron, and their
construction is well adapted for securing water-tight joints where
the covering is fixed to them. They are cast in lengths of
10 ft. 10 in., \( \frac{3}{2} \) inch in height, and \( \frac{3}{4} \) thick, the bottom flange being \( \frac{1}{4} \) inch thick. The web of the purliins is ornamental in
its own right, being a complete outline of the purliins chipped.
For connecting the purliin firmly to the rib and to give it a certain amount of lateral stiffness two ornamental
brackets are fixed by four bolts, 1 inch diameter, to the
rib, so that one end appears to support the purliin to which it
is well bolted, and the part fixed to the rib being \( \frac{1}{4} \) inch in
thickness and 54 feet long.
Under each of these brackets of \( \frac{1}{2} \) inch metal an ornamental
fret is fixed to the soffit of the rib, on which a 7 feet by
\( \frac{1}{2} \) inch board is fastened to cover the open space between L
irons. The two upper bolts of those connecting brackets to
rib serve for fixing the wind ties, the ends of which are
fastened to the usual way, and have right and left-hand
screws for adjustment.
The roof of the Exhibition Palace is covered with Italian zinc
and glass. The zinc is No. 14 gauge on rolls 3 inch by \( \frac{1}{4} \) inch,
about 1 ft. 2\( \frac{1}{2} \) in. apart. The winter garden is covered with glass on
saas bars \( \frac{1}{4} \) inch, and \( \frac{1}{4} \) inch by \( \frac{1}{4} \) inch, about 1 ft. 2\( \frac{1}{2} \) in.
apart. The glass or zinc overhangs centre of top flange of purlin 4½ inch. The ventilation in this roof is effected by a novel arrangement at the top. The ribs carry in their centre cast iron standards, which are connected at the top on each side by one L-iron 3¼ inch by 2½ inch by ½ inch, for supporting the covering and guttering. These two sides of the ribs are cast iron, and the angle iron is used for ventilation, and can be opened or shut by means of a valve consisting of a piece of convex sheet iron fixed to a spindle running along the roof and having a bearing in each of the cast iron standards. At certain places pulleys and balance weights are fastened to the spindle, from which a cord goes down to the engine room. By turning the handle, the spindles can be turned, and the opening or shutting of the ventilator controlled. The whole apparatus is covered by a piece of corrugated zinc forming the ridge, and fixed on small cast-iron supports.

The main ribs weigh each 2¾ tons. The weight of the purlines in one bay is 1 ton 1 cwt. 21 lb, and the weight of brackets for one bay is 5 cwt. 42 lb. The entire weight of wrought and cast iron in one bay, exclusive of covering, is 3 tons 14 cwt. Each of the ribs is supported by a cast-iron column, 45 feet high from floor level, in three lengths. There are other series of columns 32 feet high in two lengths, 16 ft. 10 in. apart from the columns supporting the main ribs, and the distance between the columns of the main ribs and the columns supporting the covering is 16 ft. 10 in. The first tier columns carry at a height of 15 feet cast-iron girders 2 feet deep, with ends widened out to brackets supporting the flooring of the gallery. At a height of 33 feet they carry a cast-iron arched roof of 13 ft. 5 in. clear span. The inner columns support wrought-iron struts about 8½ inches thick on the columns, and the inner curve of which completes the semicircle of 24 ft. of radius. The base of the rib is simply bolted to the top of springers with No. 6 1-inch bolts.

The horizontal thrust is transmitted by this bracket, and a flying buttress is fixed to the column. The cast-iron principal of safety of the columns is 5 inches square. The inside of each column is divided by a series of horizontal tiers, 1 ft. 8 in. thick, producing a transverse strain, this frame becomes perfectly rigid, and takes the horizontal thrust without the aid of diagonal bracing.

The columns are cast in two lengths, one portion extending to the top of the gallery girders, and the other to the lower and upper gutters in the first and second tiers. They are connected by four L-iron struts, about 3 inches thick, 4 ft. in length. These columns are cast iron, and the transverse thrust of the gallery flooring directly to the column. The greater part of the permanent and moving load of the gallery is thus brought directly on to the columns, and the gallery girders are left to take the thrust of the ribs. The columns are nearly alike, and have a uniform cross section. The supporting springing of cast-iron side roof is formed by brackets projecting from each side, leaving the column itself to pass through. The water is carried off from the gutters of the main roof by the columns. The two sides acting as flanges in relation to the transverse strain arising from horizontal thrust is 3¾ inch thick, the remaining two sides are 3¼ thick. The longitudinal girders of the gallery are connected to the columns by dovetails cast on the columns at each end, fitting into corresponding grooves cast in the ends of columns allowing 3 inch space, which is run with lead.

The bottom girders have 5 square inches sectional area in the top tongs, and are widened out at both ends so as to form a sort of square box, to which the base of the columns are attached by four 1½ inch bolts. The columns with boxes and girders rest on foundations of concrete. The flying buttresses are composed of several pieces, the joints being applied as to secure correct action and good workmanship. The weight of iron work in one bay of supporting structure is 7 tons 18 cwt.

Arched Roof of the Derby Market Hall.

The area covered by this roof is a square space 195 feet long and 88 ft. 6 in. wide. It is divided into eight bays of 24 feet each. The roof is hipped at both ends, and therefore there are only five ordinary principals of 81 ft. 5 in. clear span. The principals consist of wrought-iron arched ribs, the inner and outer curves being true circles struck from the same centre with radii of 43 ft. 9 in. and 41 ft. 5 in. respectively, the springing of rib being 7 ft. 6 in. above centre. The height of rib at crown is 62 ft. 10 in. above floor level. The wrought-iron rib is of the same depth throughout, and consists of a plate and top and bottom flanges of two L-irons 3½ by 3½ by 7-16ths.

At every alternate supporting place of the purlines the web is joined by means of a joint plate 1 ft. 9 in. by 10½ inches by ¼ inch thick, which plate is also riveted on to the other purlines as a strengthening plate. Angle irons extend from each joint to the length of the supporting purline. Riveting is done throughout by a rivet ½ inch, by 6½ inch, by ¼ inch thick, with the head being flanged out by a plate ½ inch thick. Riveting is done through the joint plate, thus effectively securing the joint.

Oxidation by casings and ornaments stuck on may be sometimes really required, but if the real working structure can be made in itself good looking its merit is by far greater. These holes (about 6 inches in diameter, the larger ones) were bored and punched out by a savior, 5 inches wide, 5 inches thick, and 8½ inches long. The column, the inner curve of which completes the semicircle of 24 ft. of radius. The base of the rib is simply bolted to the top of springers with No. 6 1-inch bolts.

The horizontal thrust is transmitted by this bracket, and a flying buttress is fixed to the column. The cast-iron principal of safety of the columns is 5 inches square. The inside of each column is divided by a series of horizontal tiers, 1 ft. 8 in. thick, producing a transverse strain, this frame becomes perfectly rigid, and takes the horizontal thrust without the aid of diagonal bracing.

The columns are cast in two lengths, one portion extending to the top of the gallery girders, and the other to the lower and upper gutters in the first and second tiers. They are connected by four L-iron struts, about 3 inches thick, 4 ft. in length. These columns are cast iron, and the transverse thrust of the gallery flooring directly to the column. The greater part of the permanent and moving load of the gallery is thus brought directly on to the columns, and the gallery girders are left to take the thrust of the ribs. The columns are nearly alike, and have a uniform cross section. The supporting springing of cast-iron side roof is formed by brackets projecting from each side, leaving the column itself to pass through. The water is carried off from the gutters of the main roof by the columns. The two sides acting as flanges in relation to the transverse strain arising from horizontal thrust is 3¾ inch thick, the remaining two sides are 3¼ thick. The longitudinal girders of the gallery are connected to the columns by dovetails cast on the columns at each end, fitting into corresponding grooves cast in the ends of columns allowing 3 inch space, which is run with lead.

The bottom girders have 5 square inches sectional area in the top tongs, and are widened out at both ends so as to form a sort of square box, to which the base of the columns are attached by four 1½ inch bolts. The columns with boxes and girders rest on foundations of concrete. The flying buttresses are composed of several pieces, the joints being applied as to secure correct action and good workmanship. The weight of iron work in one bay of supporting structure is 7 tons 18 cwt.

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At every alternate supporting place of the purlines the web is joined by means of a joint plate 1 ft. 9 in. by 10½ inches by ¼ inch thick, which plate is also riveted on to the other purlines as a strengthening plate. Angle irons extend from each joint to the length of the supporting purline. Riveting is done throughout by a rivet ½ inch, by 6½ inch, by ¼ inch thick, with the head being flanged out by a plate ½ inch thick. Riveting is done through the joint plate, thus effectively securing the joint.

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The horizontal thrust is transmitted by this bracket, and a flying buttress is fixed to the column. The cast-iron principal of safety of the columns is 5 inches square. The inside of each column is divided by a series of horizontal tiers, 1 ft. 8 in. thick, producing a transverse strain, this frame becomes perfectly rigid, and takes the horizontal thrust without the aid of diagonal bracing.

The columns are cast in two lengths, one portion extending to the top of the gallery girders, and the other to the lower and upper gutters in the first and second tiers. They are connected by four L-iron struts, about 3 inches thick, 4 ft. in length. These columns are cast iron, and the transverse thrust of the gallery flooring directly to the column. The greater part of the permanent and moving load of the gallery is thus brought directly on to the columns, and the gallery girders are left to take the thrust of the ribs. The columns are nearly alike, and have a uniform cross section. The supporting springing of cast-iron side roof is formed by brackets projecting from each side, leaving the column itself to pass through. The water is carried off from the gutters of the main roof by the columns. The two sides acting as flanges in relation to the transverse strain arising from horizontal thrust is 3¾ inch thick, the remaining two sides are 3¼ thick. The longitudinal girders of the gallery are connected to the columns by dovetails cast on the columns at each end, fitting into corresponding grooves cast in the ends of columns allowing 3 inch space, which is run with lead.

The bottom girders have 5 square inches sectional area in the top tongs, and are widened out at both ends so as to form a sort of square box, to which the base of the columns are attached by four 1½ inch bolts. The columns with boxes and girders rest on foundations of concrete. The flying buttresses are composed of several pieces, the joints being applied as to secure correct action and good workmanship. The weight of iron work in one bay of supporting structure is 7 tons 18 cwt.
mentioned, to the inner flange 10½ inch wide. The bracket in front, being only a mere web, is hidden by a casing, appearing as an ornamental boss of the same thickness as the flat box forming part of column, which is in elevation shaped like the two brackets supporting the outlets of gutter on each side. This gutter joins the column by a semi-elliptical arch forming the outlet. The casing is here required for the sake of appearance and for saving a core. To the back of the upper part of column (supporting outlet and the upper flange of the 1 iron), a frame 11 ft. 6 in. long is fixed by six large bolts. It consists of an arch of 5 ft. 1 in. radius of bottom outline, with a pretty filling in ornament, and on the top a square frame 2 ft. 6 in. deep. All the main flanges are 8 inches wide, 3½ inch thick, only the upper flange of frame 1 foot wide by 2½ inch, web being ¼ inch thick. The other end of the frame is similarly provided with a vertical flange and a lug at the bottom, forming on the wall, being besides bolted to it by four inch bolts. This frame would apparently transmit the horizontal thrust to the walls enclosing the hall, but that is not the case. The horizontal thrust is in this roof taken by a very peculiar arrangement. On the top of the frames just described, on each end strong boxes are cast on, each of which contains a pin dropped into it from above. These pins connect the ends of diagonal bracing rods, with eyes on one end and key adjustment at the other. Along the outer boxes a wrought-iron flange runs throughout the length of the building; decreasing towards the ends, the diagonals increase with them. The flange, consisting of four plates, 1 foot by 1½ inch, and two L-irons, 3 inch by 3 inch by half inch in centre, is connected by the pins to the diagonals. On the other hand, the gutter acts as the other flange of this horizontal girder, and is made sufficiently strong, being cast 1¾ inch thick. The single lengths of gutters are connected together by means of eight 2-inch holes equally spaced by the gutters, for the strength of the gutters, of course pierced the web of the T-shaped part of column. The gutter being cast-iron, and sometimes exposed to tensile strains, requires, therefore, the above-mentioned area. There are eight diagonals, one for each bay, the dimensions of the room increases from the centre towards the ends. The diagonals having to sustain the whole of the flanges, the strains must be always of the same sections as them, because they can only act as the ties. At the hip of the roof only simple ties are required as diagonals.

The roof offering in its longitudinal direction a very great resistance renders it unnecessary to provide for an extra horizontal thrust arising out of the great force of column. The gutter, being 1 foot by 5½ inch deep, 1 foot wide, and 23 feet by 4 inches long, 1¾ inch thick, has in distances of 3 feet small shoes cast on, which receive the ends of the intermediate rafters 6 inches by 3 inches. The rafters are placed across the 13 foot window at a proper slope, laid with 1 inch boarding, and covered, like the large roof, with the outer ends of the rafters rest in shoes on the wall surrounding the hall. The gutter is covered by a snow girding, which is 1 foot by 3 inches wide, and cast in length of 6 feet. It rests on small supports fixed by two ½ inch bolts to cross pieces cast on the gutter at every second pair of shoes, and serving as distance pieces in the casing, while it cools and prevents it from warping into awkward shapes. These distance pieces must always be made with a top flange; otherwise the other parts of casings prove stronger in shrinking and tear it in the middle. The rain-water is carried sideways by the bracket-shaped outlets of gutter in the column and carried off exactly same to the drain-pipes. The cast and wrought ironwork of this roof weighs 14½ tons. The cast and wrought ironwork of one bay of supporting structure weighs 17½ tons. (To be continued.)

TOWN HALL AND CORN EXCHANGE, FARNHAM, SURREY.

The new buildings, which have been in course of erection during the last twelvemonth, and are now completed, were opened on the 15th inst., being occupied by the market office, which includes in market hall or corn exchange, offices, shops, and assembly rooms, has been built on the site lately occupied by the Goat's Head Inn, at the junction of Castle-street with the Borough. At the corner of the building is a clock-tower, 88 ft. high, in the top story of which is a four-dial clock, by Frodsham, presented to the town by Mr. S. Nicholson, of Waverley Abbey. This

tower is surmounted by a belfry, having a slated spire, terminated by a weather-cock, and containing three bells, for the quarters and hour. On the side next the Borough are shops, with cellars below, and a large room for the borough meeting. On the side next Castle-street is occupied by offices, with an entrance-hall, 33 ft. by 10 ft. in the centre, paved with black and red tiles, for access to the market-hall, which is built behind the shops, and is lighted from the roof and one end. This hall is 70 ft. by 36 ft., and 30 ft. high; it is faced inside with white Huntingdon bricks, slightly relieved with red and black bricks. It is covered by a polychromed ceiling resting on circular arches, formed of three thicknesses of 3-inch planks, bolted together on the Delorme principle, which spring from stone corbels on projecting piers. One compartment of the ceiling on each side of the centre one is filled with rough plate-glass the whole length of the hall, and there is a three large-light window at one end of the roof. The rest of the ceiling is boarded, the whole of the woodwork being stained and varnished. On one side of the hall, and entered from it, are offices for the use of merchants attending the markets; there is also a side entrance to the room from the Borough.

The assembly-room is placed on the upper floor, and in the portion of the building fronting Castle-street. This is reached by three separate stone staircases, the chief of which is 7 feet wide, and leads from the entrance-hall in Castle-street. The room is 48 feet by 33 feet, and 30 feet high, with retiring-room and cloak-room adjoining. Its roof and ceiling are constructed on the same principle as those of the central room, being supported from carved stone capitals, supported on red shafts of terracotta. Both this room and the market-hall are lighted by sunburners of Messrs. Strode's manufacture, and are warmed by Harlen's hot-air apparatus.

The outside of the building, and also the staircases and entrance-hall, are faced with white Huntingdon bricks. All round the roof of the assembly-room is an arched parapet, surmounting a moulded cornice, all of terra-cotta; and the arches to the chief entrances are of the same material. The mullions of the windows are of Bath stone, with carved caps and red terracotta pillar shafts. The entrance doors have carved panels, with red terracotta shafts. Carved stone caps and red shafts are also used at the outer angles of the lowest stage of the tower, and also at the arched openings at the base of the tower. The windows have gauged semi-circular and segmental arches of moulded red bricks, with stone keys and skew backs. All quoins, window and door jambs, arches of terracotta, and panels for clock-faces, are of Bath stone.

The terra-cotta was supplied by Mr. Blashfield, of Stamford. Mr. F. Biele, of Farnham, was contractor for the general building; and Mr. R. Mulley acted as clerk of works. The architect employed was Mr. E. Wyndham Tarn, of London. The total cost has been about £2300. The style of the building is an adaptation of that prevalent in Italy during the eleventh and twelfth centuries.

ON THE FORCES CONCERNED IN LAYING AND LIFTING DEEP-SEA CABLES.*

By WILLIAM THOMSON, LL.D.

The forces concerned in the laying and lifting of deep submarine cables attracted much public attention in the years 1857–58.

An experimental trip to the Bay of Biscay, in May 1858, proved the possibility not only of safely laying such a rope as the old Atlantic cable in very deep water, but of lifting it from the bottom without fracture. The speaker had witnessed the almost incredible feat of lifting up a considerable length of that cable and seemingly fragile thread from a depth of nearly two and a half nautical miles.† The experiment was done with the safety of the ship, the rigging, and actually lifting the cable out of the water, the latter being a proof that the cable had been actually submerged. The cable was found to be of very considerable weight, having a large weighted frame attached to it, to prevent untwisting between the two ships, from which two portions of cable with

* Read before the Royal Society.
† Throughout the following statements the word mile will be used to denote not that most meaningless of modern measures, the British statute mile, or the length of a minute of latitude, in mean latitudes, which in electric cable laying is taken as 5015 ft. For approximate statements, rough estimates, etc., it may be taken as 5000 ft. or 1500 fathoms.
opposite twists had been laid. The actual laying of the cable a few months later, from mid-ocean to Valentia on one side, and Trinity Bay, Newfoundland, on the other, regarded merely as a mechanical achievement, belongs to the story of those great
and celebrated engineers of the day, who had not concealed their opinion that the Atlantic Telegraph Company had undertaken
an impossible problem. As a mechanical achievement it was
completely successful; and the electric failure, after several
hundred messages (comprising upwards of 4359 words) had
been successfully transmitted, was due to the fact that, with
the possibility of damage being done to the submarine cable
owing to electric faults existing in the cable before it went to
sea. Such faults cannot escape detection, in the course of the
manufacture, under the improved electric testing device brought
into practice, and the causes which led to the failure of the
first Atlantic cable no longer exist as dangers in submarine
telegraphic enterprises. But the possibility of damage being
done to the insulation of the electric conductor before it leaves
the ship (illustrated by the occurrences which led to the tem-
porary loss of the 1865 cable), implies a danger, which can
only be thoroughly guarded against by being ready at any
moment to back the ship and check the egress of the cable,
and to hold on for some time, or to haul back some length,
according to the results of electric testing.

The forces concerned in these operations, and the mechanical
arrangements by which they are applied and directed, constitute
one chief part of the present address; the remainder is devoted
to explanation as to the problem of lifting the last end of the
1865 cable from the bottom, that laid last under the Straits of
Vieira, and now lying in perfect electric condition (in the
very safest place in which a submarine cable can be kept), and
ready to do its work, as soon as it is connected with New-
foundland, by the 600 miles required to complete the line.

Force or Submarine Submergence.—In a paper published in 1857, the speaker had given the differential
equations of the catenary formed by a submarine cable between
the ship and the bottom, during the submergence, under the
influence of gravity and fluid friction and pressure; and he
had pointed out that the curve becomes a straight line in the
case of the cable being in contact with the bottom. In the case
of deep-sea cable laying, he made no further reference to
the general problem in the present address.

When a cable is laid at uniform speed, on a level bottom,
quite straight, but without tension, it forms an inclined straight
line, from the point where it enters the water, to the bottom,
and to hold on for it clearly moves uniformly in a straight line
towards the position on the bottom that it ultimately occupies.*
That is to say, each particle of the cable moves uniformally along
the base of an isosceles triangle, of which the two equal sides
are the inclined portion of the cable between it and the bottom,
and the line along the bottom which this portion of the cable
covers. When the cable is laid in a straight line, and the ship is
at a rate exceeding that of the ship's progress, the velocity and
direction of the motion of any particle of it through the water
are to be found by combining a velocity along the inclined
side, equal to this excess, with the velocity already determined
along the base of the isosceles triangle.
The angle between the equal sides of the isosceles triangle, that
is to say the inclination which the cable takes in the water,
is determined by the condition, that the transverse component
of the cable's weight in water is equal to the transverse component
of the resistance of the water to its motion. Its tense where it
enters the water is equal to the longitudinal component of the cable
weight (or, which is the same, the tension of cable hanging
down vertically to the bottom), diminished by the longitudinal component of the fluid resistance. In the laying of the Atlantic cable, when the depth was two miles, the rate of the
ship six miles an hour, and the rate of paying out of the cable
seven miles a minute, a resistance of 14 cwt. accurately measured
by a dynamometer, was only 14 cwt. But it must have been as much as 28 cwt., or the weight of two miles of the cable hanging vertically down in the water, were it not for the
frictional resistance of the water against the cable slipping,
as it were, down an inclined plane from the ship to the bottom,
which, therefore, must have borne the difference, or 14 cwt.

Accurate observations are wanting as to the angle at which the
cable entered the water; but from measurements of angles at the
stem of the ship, and a dynamical estimate (from the measured
strain) of what the curvature must have been between the ship
and the water, I find that its inclination in the water, when the
ship's speed was nearly 62 miles per hour, must have been about
36°. It shows that there was a considerable, but very small error, as simply the excess of the speed of paying out above the speed of the ship, or about one mile an hour.

Hence, to haul up a piece of cable vertically through the
water at the rate of one mile per hour would require less than 1
cwt. for overcoming fluid friction per mile of the cable, over and
above its weight in water. Thus fluid friction, which for the
laying of a cable performs so valuable a part in easing the strain
with which it is payed out, offers no serious obstruction, indeed
scarcely any sensible obstruction to the reverse process of hauling
back, if done at only one mile an hour, or any slower speed.

As to the transverse component of the fluid friction, it is to be
remarked that, although not directly assisting to reduce the
egress strain it indirectly contributes to this result; for it is the
transverse friction that causes the gentleness of the slope, giving
the sufficient length of seventeen miles of cable slipping down
through the water, on which the longitudinal friction operates,
to reduce the egress strain to the very safe limit for the first time.
In the preceding year, when the first mile was laid, if the slope
were as much as 1 in 5, we should commit only an insignificant
error if we supposed it to be simply equal to the weight of the
cable in water, or about 14 cwt. per mile for the 1865 Atlantic
cable. The transverse component velocity to which this is due
may be estimated with but insignificant error by taking, as the
velocity of a body moving directly to the bottom in the time
occupied in laying a length of cable equal to the seventeen
miles of oblique line from the ship to the bottom—the therefore it
must have been from 2 miles in 17 = 64 = 2½ hours, or of 8
of a mile per hour. It is not probable that the actual motion of the cable in water was quite so much.
Thus, the velocity of settling of a horizontal piece of the
cable (or velocity of sinking through the water, with weight
just borne by fluid friction) would appear to be about 8
of a mile per hour. This may be contrasted with longitudinal friction
by remembering that, according to the previous result, a lon-
titudinal motion through the water, at the rate of 62 miles
per hour is resisted by only one-seventeenth of the weight of
the portion of cable so moving.

These conclusions justify remarkably the choice that was made
of materials and dimensions for the 1865 cable. A more compact
one (for instance, with less gutta-percha, less or no tow
round the wires, etc.), would have been more in resisting
strength and equal weight per mile in water, would have expe-
rienced less transverse resistance to motion through the water,
and therefore would have run down a much steeper slope to the
bottom. Thus, even with the same longitudinal friction per mile,
it would have been less resisted on the shorter length; but even
on the same length it would have experienced much less longitudi-
nal friction, because of its smaller circumference. Also, it is
important to remark that the roughness of the outer tow covering
undoubtedly did very much to ease the egress strain, as it must
have increased the fluid friction greatly beyond what would
have acted on a smooth gutta-percha surface, or even on the surface of
smooth wood as was presented by the more common form of sub-
marine cables.

The speaker showed models illustrating the paying-out ma-
chines used on the Atlantic expeditions of 1858 and 1865. He
stated that nothing could well be imagined more perfect than the
actual machine used in laying the cable then laid, and that if it
were only to be used for paying out no change, either in general plan or in detail, seemed desirable, except the substitution of a softer material for the "jockey pulleys," by which the cable in entering the machine has the
small amount of resistance applied to it, which it requires to keep
it from slipping back on the main drum. The rate of egging of
the cable was kept always under perfect control by a weighted
friction brake of Appold's construction (which had proved its
good quality in the 1858 Atlantic expedition) applied to a second drum
carried on the same shaft with the main drum. When the
weights were removed from the brake (which could be done

* Precisely the movement of a battalion in line changing front.
almost instantaneously by means of a simple mechanism) the resistance to the egress of the cable produced by "jockey pulleys," and the friction at the bearings of the shaft carrying the main drum, &c., was about 24 cow.

For the Cable in case of the Appearance of an Electric Fault during the Laying.—In the event of a fault being indicated by the electric test at any time during the paying out (as proved by the recent experience) the safe and proper course to be followed in future, if the cable is of the same construction as the present Atlantic cable, is instantly, on order from the skipper or in the electric room on the ship's engines, and to put on the greatest safe weight on the paying-out brake. Thus in the course of a very short time the egress of the cable may be stopped, and if the weather is moderate, the ship may be kept, by proper use of paddles, screw, and rudder, nearly enough in the same position for the two wires to drop down almost vertically, with little more strain than the weight of the length of it between the ship and the bottom.

The best electric testing that has been pracised, or even planned, cannot show within a mile the position of a fault consisting of a slight loss of insulation, unless both ends of the cable are at hand. Whatever its character may be, unless the electric tests demonstrate its position to be remote from the outgoing part, the only thing that can be done to find whether it is just on board or just overboard, is to cut the cable as near the outgoing part as the mechanical circumstances allow to be safely done. The electric test immediately transferred to the fresh-cut seaward end shows at once the end of the line of failure, between the shore and the ship. A few minutes more, and the electric tests applied to the two ends of the remainder on board will, in skilful hands, with a proper plan of working, show very closely the position of the fault, whatever its character may be. The engineers will thus immediately be able to make proper arrangements for replacing and paying out good cable, and for cutting out the fault from the bad part.

But if the fault is between the land end and the fresh-cut seaward end on board ship, proper simultaneous electric tests on board ship and on shore (not hitherto pracised, but easy and sure if properly planned) must be used to discover whether the fault is to haul back the cable until it is got out board. If it is so, then steam power must be applied to reverse the paying-out machine, and by careful watching of the dynamometer, and controlling the power accordingly (hauling in slowly, stopping, or veering out a little, but never letting the dynamometer show over 15 or 20 tons), the cable will, if the delicacy be kept sufficiently high (which with 7 or 8 volts will not break, and the fault can be got on board more surely, and possibly sooner, than a "milky" salmy of 30 lb. can be Laded by an expert angler with a line and rod that could not bear 10 lb). The speaker remarked, that he was entitled to make such assertions with confidence now, because the experience of the last year and of the new line, and the estimates of the scientific committee, and of the contractors, as to the strength of the cable, its weight in water (whether deep or shallow), and its mechanical managability; but he had proved that in moderate weather the Great Eastern could by skilful seamanship keep in position and moved in the manner required. She had actually been so for thirty-eight hours and eighteen minutes during the operations involved in the hauling back and cutting out the first and second faults, and re-uniting the cable, and, during seven hours of hauling in, in the attempt to repair the third fault.

Should the simultaneous electric testing on board and on shore prove the fault to be 50 or 100 or more miles from the ship, it would lie so near the ship that the height of the put up, the season of the year, and the means and appliances on board, whether it would be better to complete the line, and afterwards, if necessary, cut out the cable and repair, or to go back at once and cut out the fault before attempting to complete the line. Even the worst of these contingencies would not be fatal to the undertaking with such a cable as the Atlantic. But experience shows that almost certainly the fault would either be found on board, or but a very short distance overboard, and would be reached and cut out with scarcely any risk, if really prompt measures, as above described, are taken at the instant of the appearance of a fault, to stop, as soon as possible with safety, the further run of the cable.

The most striking part of the Atlantic undertaking proposed for 1866, is that by which the 1200 miles of excellent cable laid in 1865 is to be utilised by completing the line to Newfoundland.
or as soon as possible after, to grapple and lift at a point about three miles farther eastward. This could be well and safely done by two ships, one of them with a cutting grappling, and the other (the Great Eastern herself) with a holding grappling. The latter, on hooking, should haul up cautiously, never going beyond a safe strain, as shown by the dynamometer. The other, when assured that the Great Eastern is well grappled, will grapple the cable as far eastwards (even if partly lying along the bottom at first), and allow the Great Eastern to haul up and work slowly eastwards, so as to keep its grappling rope, and therefore ultimately the portions of the cable hanging down on the two sides of its grappling, as nearly vertical as is necessary to make sure of getting the cable on board. This plan was illustrated by lifting, by aid of two grappling, a very fragile chain (a common brass chain in short lengths, joined by links of fine cotton thread) from the floor of the Royal Society. It was also pointed out that it can be executed by one ship alone, with only a little delay, but with scarcely any risk of the chain breaking the cable by unloading grappling, and hauling it up 200 or 300 fathoms from the bottom; it may be left there hanging by the grappling rope on a buoy, while the ship proceeds three miles westwards, cuts the cable there, and returns to the buoy. Then it is an easy matter in any moderate weather to haul up safely, and get the cable on board.

The use of the dynamometer in dredging was explained; and the forces operating on the ship, the conditions of weather, and the means keeping the ship in proper position during the process of slowly hauling in a cable, even if it were of strength quite insufficient to act when nearly vertical with any sensible force on the ship, were discussed at some length. The manageability of the Great Eastern in skilful hands had been proved to be very much better than could have been expected, and to be sufficient for the requirements in moderate weather. She has both screw and paddles—an advantage possessed by no other steamer in existence. By driving the screw at full power head, and backing the paddles to prevent the ship from moving ahead, or (should the screw overpower the paddles) by driving the paddles full power astern, and driving at the same time the screw ahead with power enough to prevent the ship from going astern, "steering way" is created by the leeward of water from the screw against the rudder, so that the Great Eastern may be effectively steered without going ahead. Thus she is in calm or moderate weather almost as manageable as a small tug steamer with reversing paddles, or as a rowing boat. She can be made still more manageable than she proved to be in 1865, by arranging to disconnect either paddle at any moment; which, the speaker was informed by Mr. Canning, chief engineer of the Telegraph Construction and Maintenance Company, informing him that it is intended to use three ships, and to be provided both with cutting and with holding grapples, and expressing great confidence as to the success of the attempt. In this confidence the speaker believed every practical man who witnessed the Atlantic operations of 1865 shared, as did also, to his knowledge, other engineers who were not present on that expedition, but who were well acquainted with the practice of cable-laying and mending in various seas, especially in the Mediterranean. The more he thought of it himself, from both what he had witnessed on board the Great Eastern and from attempts to estimate on dynamical principles the forces concerned, the more confident he felt that the contractors would succeed next summer in utilising the cable partly laid in 1865, and completing it into an electrically perfect telegraphic line between Valentinia and Newfoundland.

By the expedition of 1865 it has been fully demonstrated:
1. That the insulation of a cable improves very much after its submersion in the cold deep water of the Atlantic, and that its conducting power is considerably increased thereby.
2. That the steamship Great Eastern, from her size and constant steadiness, and from the control over her afforded by the joint use of paddles and screw, renders it safe to lay an Atlantic cable in any weather.
3. That in a depth of over two miles four attempts were made to grapple the cable. In three of them the cable was caught by the grappling, and in the other the grappling was fouled by the chain attached to the cable.
4. That the paying-out machinery used on board the Great Eastern worked perfectly, and can be confidently relied on for laying cables across the Atlantic.
5. That with the improved telegraphic instruments for long submarine lines a speed of more than eight words per minute can be obtained through such a cable as the present Atlantic between Ireland and Newfoundland, as the amount of slack actually paid out did not exceed 14 per cent, which would have made the total cable laid between Valentia and Heart's Content less than 1900 miles.
6. That the present Atlantic cable, though capable of bearing a strain of 7 tons, did not experience more than 14 cwt. in being payed out into the deepest water of the Atlantic between Ireland and Newfoundland.
7. That there is no difficulty in mooring buoys in the deep water of the Atlantic between Ireland and Newfoundland; and that two buoys, even when moored by a piece of the Atlantic cable itself, which had been previously lifted from the bottom, have ridden out a gale.
8. That more than four nautical miles of the Atlantic cable have been recovered from a depth of over two miles, and that the insulation of the gutta-percha-covered wire was in no way whatever impaired by the depth of water, or the strains to which it had been subjected by lifting and passing through the hauling-in apparatus.
9. That the cable of 1865, owing to the improvements introduced into the manufacture of the gutta-percha core, was more than one hundred times better insulated than cables made in 1866, then considered perfect, and still working.
10. That the electrical testing can be conducted at sea with such unerring accuracy as to enable the electricians to discover the existence of a fault immediately after its production or development, and very quickly to ascertain its position in the cable.
11. That with a steam engine attached to the paying-out machinery, should a fault be discovered on board while laying the cable, it is possible that it might be recovered before it had reached the bottom of the Atlantic, and repaired at once.

S. CANNING (Engineer-in-Chief, Telegraph Construction and Maintenance Company).
JAMES ANDERSON (Commander of the Great Eastern).
DANIEL GOOCH, M.P. (Chairman of Great Ship Company).
HENRY CLIFFORD (Engineer).
WILLIAM THOMSON F.R.S. (Prof. of Natural Philosophy in the University of Glasgow).
CROMWELL F. VARLEY (Consulting Electrician of Electric and International Telegraph Company).
WILLOUGHBY SMITH.
JULES DESPECHE.

New Zealand Canals.—A proposal has been made for the construction of a canal uniting the navigation of the Kaipara and Waitamata and the settlement of a block of provincial land of about 450,000 acres. In the Kaipara district there is an immense territory of agricultural land, and generally of good quality. This land is accessible by the land-locked sea known as the Kaipara, and by navigable rivers and canals providing easy and available means of inland transit, but it is cut off from Auckland, effectually as if it were on the west coast of Canterbury, for all purposes of trade and commerce. A canal of a few miles through what might be called a level country, from Brightwater's Creek to the headwaters of the Kaipara, would connect the port of Auckland with that district, and make available to river steamers and barges of light draught about 300 miles of tidal river navigation. The block of land proposed to be given to any company which will construct the canal and cultivate the land is intersected by two navigable rivers. It is generally rich agricultural land.
ROADS IN INDIA.

There is a question which must soon be faced by the government of India, scarcely less momentous to the welfare of the people, and fully as vast in its proportions, as that of irrigation. Sir John Lawrence, in his evidence before the Committee of the House of Commons on the Colonization of India, said, "we are perishing for want of roads." The expression was not only metaphorically, but literally, true. But for the want of roads, the famines, caused by the absence of irrigation, could never assume the extent or severity that they do. Something has been done to equalize the distribution of food by the construction of the trunk railways; but, without connecting highways, the peasant, 60 or 100 miles distant from a town, can get into the jungle, ravine, and morass, might as well be a thousand miles off.

Those who have had occasion to travel much in the interior of the country, away from the few great roads which have crept slowly into existence during our century of occupation, must have often had the urgency of this need forced upon their attention. The traveller, as he watches that marvellous combination of sticks and string in which four half-starved oxen drag painfully along his baggage, at the rate of a mile and a half an hour, over hedge and ditch, or through ploughed fields, cannot but speculate on what India might now have been, had twenty or thirty millions been expended in a worthy system of roads thirty years ago. Whatever Sir Charles Wheatstone may boast in the House of Commons and local governments in their administration reports, about the thousand miles of "road" constructed under our sway, every sportsman, every engineer, and every settler, to his cost, knows that, besides the Grand Trunk Road and a few branches, there is scarcely a road through the Bengal of which he is not boastful.

What these "thousands of miles" are, may be supposed from the fact that, in one district at least, as published in an official administration report a few years ago, they cost twelve shillings a mile! The truth is, that two arrows are run with a plough, 50 or 60 feet apart, right across country, hedges and ditches being left to be levelled by successive carts tumbling over or into them, and there you have a "district road." Many of them are simply water-courses, actually sunk six or eight feet below the surface of the country; and we have seen perpendicular falls of three or four feet, with a fine cascade rushing over them, extending right across the road. A mere common obstruction is an irrigation channel, taking the form either of a deep ditch, or an embanked duct, two or three feet high, by which the zemindars have cooly blocked up the road for convenience of irrigation.

Bad as such roads are, they have the advantage of being visible, and so serving as a guide from place to place. But they exist only as a single mile at a time, no road at all between town and town; carts follow each other's ruts over the cultivation, sometimes establishing a defined track for a few hundred yards, but which again disappears in the middle of a ploughed field further on. The zemindars, not content with ploughing up the track, cut bushes, and plant thorns-bushes across it, to drive the carts to take another route, which they are in turn diverted by the cultivators of the ground.

A considerable sum of money is spent by local committees from local funds, on communications, but we fear that a great deal of it is simply wasted. Except in the North West Provinces, where there is a civil engineer for each commissioner's division, the money is disbursed without any professional advice or supervision, and hence embankments are made where none are wanted, and vice versa; bridges tumble down or are left high and dry, and little good is done. Every civil officer is supposed to be able to lay out a road or build a bridge; although he would probably hesitate about the calculation to make the structure safe. In France all public highways and bridges are under the charge of a highly educated corps of civil engineers, the department of Ponts et Chaussées, and even in England, where we delight to do everything the wrong way, the system of parish roads is forced upon the local authorities by the boards who are competent surveyors to advise them. How long will it be before our government accepts the principle of division of labour?

The melancholy results of leaving professional matters like road-making to civil authorities, who have neither the knowledge nor the leisure to supervise them, are nowhere more conspicuous than in the present roads of India. We are, excluding, of course, those under the Public Works Department.

The aggravating way in which these roads are often aligned, can only be accounted for by a combination of the original per-
is not the worst of evils; if war comes we pocket the necessity, and borrow, though the money never returns. Why not borrow when the need is so urgent, and the results so beneficial? Canals may be made by private companies; roads cannot. The railways will never have a fair chance till a proper system of roads feeds them; many of them will continue to be a burden on Government for the guaranteed interest. Suppose we have to pay a million a year to the railway shareholders, will it not be economical to raise twenty millions, wherewith to make roads, that will enable the railways to pay their 5 per cent, and relieve us of this incubus? We shall still only have to pay a million to fund-holders instead of to railway shareholders, but we shall be the gainers by twenty millions worth of roads into the bargain. The railway interest, and the cotton interest together, are all-powerful in the House of Commons; why do they not unite in pressing the Government to give India her crying wants, case and roads?—Calcutta Engineer.

The Principal Ruins of Asia Minor, illustrated and described by CHARLES TEIXIER and R. POPPLEWELL PULLAN, F.R.I.B.A.

Day and Sons, 1865. Folio.

Asia Minor has proved, as far as it has been examined, a fertile field of architectural and antiquarian research, and that in more phases of art than one; and yet there is something of the charm of novelty still lingering about the discoveries made or to be made, which enables this region, for my purpose, to be regarded as unexplored, and consequently less visited, than Magna Grecia, Sicily, and Italy, and much of its wealth is but partially known. The early Christian Churches of Rome or Ravenna, and the Greek remains of Athens or Syracuse, are well catalogued and have been thoroughly explored and described; but the region of Asia Minor both of Classic and early Christian character, which it has been the province of recent explorers to make known for the first time to the world at large.

The work before us proposes to introduce to the attention of its readers the principal of those ruins which display the character of Classic architecture and sculpture, to be found in various cities along the eastern shores of the Aegean Sea. It appeals, of course, first and chiefly to the attention of students of Greek architecture, but these are in the present day less numerous than they were—far less so than they ought to be—and the work, perhaps wisely, has been thrown into a shape which, while not altogether in the method of the old architect, is sufficiently free from wearisome technical minutiae to have a claim on the attention of non-professional readers; in fact, it is a work which all persons of taste and culture will be glad to possess.

It is a record, and is regretted by all who would desire to see the architecture of this country assume a place in every respect worthy of our national eminence in other arts, that attention is too exclusively directed to the works of the middle ages, and to the phase of art to which those works belong. Pure beauty of form, refinement, proportion, symmetry, and dignity, are described, but these are the works of the Greek art in the height of the middle ages; and we cannot hope to retain these properties in our sculpture and architecture without a constant recurrence to the Greek source. We welcome, consequently, the appearance of a work like Mr. Pullan’s, for the sake of the progress of art, as well as for its sake, and we believe that it will furnish an effective contribution towards the art education of the present day.

We have called this Mr. Pullan’s book, because, although M. Texier’s name appears on the title page, this volume being, in fact, a kind of abridgment of that traveller’s large work, the responsibility and the interest of the work is, as public opinion, to Mr. J. Eden, who has transcribed and condensed from Texier’s work much of the information contained in the letterpress, and has selected the plates here given, and has added some very interesting and valuable matter of his own.

Mr. Pullan’s introduction gives a succinct history of the expeditions of Asia Minor which have been carried on by various travellers; commencing with Paul Lucas, who in 1699 traversed the peninsula, but whose work is described as unsatisfactory and incorrectly illustrated; down to his own exact and comparatively recent explorations. This is extremely well though briefly done, and will enable the reader, whose curiosity may be excited by the volume under review, to understand where he may find supplemental information. Of all the various travellers and exploring expeditions which have visited the ruins of Asia Minor, the work which published so complete a record as the French Government expedition, under Mons. Texier, and it is to render the subject matter of this very large and costly volume accessible that the present publication is undertaken.

A map and fifty-one plates, the execution of some of which is extremely beautiful, are given. They refer to the thirteen or fourteen different ruins which have been selected from a large number for illustration, as being the most important and typical. The principal subjects are the Doric Temple at Assos, the Temple of Apollo Branchides, that of Jupiter at Aizani, and that of Venus at Aphrodisias, the temple at Aizani, Apussus, and Myra, and the Temple of Augustus at Anemura.

A peculiar feature in the temples here illustrated is the extensive peribolus, or sacred enclosure, within which stood the temple itself. This has entirely disappeared in the case of the vast temple of Apollo Branchides where it was of great size, but it is still traceable at Aizani and Aphrodisias; and the details of the order from the Doric to the Corinthian are shown. The modern architect called upon to consider the problem, so well solved in these buildings, of how to accommodate a very large number of spectators so that they may all hear, see, and be seen, with perfect comfort and safety.

Throughout the work, both details and general drawings of the various buildings are given, so that by the help of them the reader will be well able to appreciate the peculiarities and the great beauties of the buildings illustrated, and we heartily echo the wish expressed by the writer in his preface, that these examples, carefully measured, accurately drawn, and well described, as they are, may be extensively studied, and may tend to promote the improvement and advancement of our taste in architecture.

We propose to conclude by giving some extracts from the introductory matter prefixed to the work itself, showing the history of the principal publications, and first of the Dilletante Society.

"As an appreciation of the elegant architecture of the Greeks became more general, the want of correct delineations was much felt, especially by scholars and antiquaries. Consequently, in 1746, the Society of Dilletants, which was founded in 1724 by a number of gentlemen who had travelled on the Continent, and who were desirous of improving the public taste in matters relating to architecture, resolved to send out properly-qualified persons to the East, 'in order to collect information, and make observations relating to the ancient cities, temples, such monuments of antiquity as were still remaining.' Dr. Chandler was selected as Director to an Expedition, Mr. Beckett as architect, and Mr. Pars as painter. They left England in June 1746, and returned in September 1750, having visited during that period the Troad, Smyrna, Casmomene, Teos, Ephesus, Miletus, Priene, Horsakia, Mylasa, Stratoniassos, Trales, Laodicea, Hierapolis, Colossae, Sarissi, Pergamus, and Thyatira. The results of their labours were published in a 400 volume by Dr. Chandler, in 1775, in two folio volumes of plates with descriptions, issued by the Society in 1769, under the title of 'Antiquities of Ionia,' in which there were two editions. The architectural details of several temples are given in this volume, well drawn and engraved; but as the Mission had no funds for excavations, the information obtained was in many cases incomplete.

"In 1811, a second Mission was dispatched to the Levant to obtain further information, consisting of Sir William Gell, accompanied by two architects, Messrs. Gandy and Bedford. They were instructed to visit Samos, Sarissi, Aphrodisias, Hierapolis, Trales, Laodicea, Telesinus, Halicarnassus, Magnesia ad Mandrum, Priene, and Branchidae; and several places in Greece. The results were published in a third volume of the 'Ionian Antiquities,' and in the 'Inedited Antiquities of Attica.'"

After a reference among other travellers to the distinguished and accomplished Professor Cockerell, whose observations in Asia Minor unfortunately remain for the most part unpublished to this day, our author comes to Mons. Texier.

"In 1833, M. Guizot, the enlightened Minister of Public Instruction
in France, commissioned M. Charles Texier to explore Asia Minor and Persia. M. Texier spent several years in these countries. He passed through Bithynia and the central provinces, and returned to Constantinople, afterwards visiting Myria, Adria, Caria, Lycia. He made careful observations of all the country, for the purpose of thoroughly investigating the works of the ancient people. These were published by the order and at the cost of the French Government, upon his return to Europe, in three folio volumes. The engravings were by the best artists, and executed at great cost. On account of the expense of the work, it has not been generally accessible; consequently the beautiful edifices illustrated in it have not been studied as much as they deserve.

"A second Expedition was undertaken by M. Texier, for the purpose of removing the remains of the Temple of Diana Leucophryne at Magnesia ad Maeandrum. This operation was successfully performed. The vase of Persæus, the Temple of the Fortune of Assos also were then obtained for the collection of the Louvre."

The English expedition, and the visit made by Mr. Pullan himself are thus referred to.

"In 1852 Mr. C. Newton, now keeper of Greek and Roman antiquities in the British Museum, was appointed Vice-Consul at Miletus, chiefly in the interest of art and archaeology. He thoroughly explored most of the islands, and frequently visited the mainland, where he made many interesting discoveries. It had been his ambition to discover the site of Mausolus and Caria, which, in his opinion, was one of the seven wonders of the world. In 1852 he visited Budrum, and there found traces of fine Greek sculpture sufficient to induce him to ask assistance from the Government, which was at once granted. A ship was provided with the necessary stores, and under the command of the Royal Engineer, Lieut. Smith, and a detachment of sappers, were despatched to aid him in his operations. In the month of January 1857, he had the satisfaction of ascertaining without doubt that he had come upon the site of the Mausoleum, and before the expiration of the year he had obtained sufficient architectural data to determine the plan of the monument and its general dimensions: and he had brought to light the magnificent series of sculptures now in the British Museum. In December 1857, Mr. Newton proceeded to Cnidus, for the purpose of exploring that ancient city, the ruins of which had been visited by Sir William Gell and the second Mission of the Dilettant Society. Here he made excavations on the site of the Temple of Venus, at the Lion Tomb, the lower part of which he restored. During the years 1857–8 Mr. Newton and Lieut. Smith were enabled to explore the whole of that part of Caria, from Labandra and Euromos to the Bay of Marmarica, opposite the island of Rhodes. Amongst other discoveries made was that of the Ruins of the Temple of Hecate at Lagina, with the sculptures of the friezes in tolerable preservation. Lieut. Smith identified the site of Labandra, where was situated the celebrated Temple of Jupiter; and Myasia, Myndus, Bagalrica were visited, and the island of Cos was thoroughly explored. Mr. Newton also visited the ruins of the Temple of Apollo, Baldram, and brought back, in a small box, part of the beautiful carvings which led to the series of figures now in the eastern gallery of the British Museum. In 1857 I was sent out by the Government to join the Expedition, with which I remained a year. During this time I visited Budrum and Cnidus, explored the island of Cos, and upon my way home visited the site of Troy and Thessalonica."

"In 1861, the Dilettant Society being desirous of obtaining further information as to the state of the sites of certain ancient temples, commissioned me to visit them, and report to them as to the desirability of excavation at the following places:—The Temple of Bacchus at Teos, which, though it had been visited by a former mission, had not been thoroughly explored. The Temple of Apollo Smintheus in the Troad, the remains of which had been discovered by Captain Spratt. The Temple of Minerva at Priene, and that of Apollo Brahida at Miletus, which had been visited by the Budrum Expedition. During the journeys necessary for exploration, I visited the whole coast northward to the Troad from the point that had been reached by Mr. Newton, and in this month of March I visited Menoece, and Cape Lectum, on the northern side of the Gulf of Adynittium, completed a survey of the coast of Caria, Iasia, and Adria, where we know the finest buildings erected by the Greek colonists formerly existed. Upon the receipt of my report, the Director General hastened to the Temple of Bacchus at Teos thoroughly explored. This was done by me in the section of 1860, and the details obtained enabled me to complete a restoration of this celebrated building, which I have reason to believe will eventually be published."

"In the present work illustrations of the finest examples of temples and other buildings, drawn by M. Texier will be found, as well as short descriptions taken from his writings and from those of other travellers in Asia Minor, and preceded by an outline of the various excursions made by me for the survey of the coast. This, it is hoped, may prove of some utility to the tourist, and aid in adding something little to what is already known of the antiquities of this most interesting country."
THE HYDRAULIC LIFT GRAVING DOCK.

A paper by Mr. Edwin Clark, on the above subject, of which the following is an abstract, was lately read at the Institution of Civil Engineers.

It was stated that this invention dated as far back as the year 1827. At that time the Victoria and London Docks had not been completed; and the engineer, Mr. Bidder, being anxious to adopt some cheaper system of docking large vessels, than by an ordinary graving dock, or any modifications of it, considered various schemes for floating docks. These were, however, all found to be more or less objectionable, from the difficulty of design, the large floating strength, and especially the necessity to preserve their form under very variable strains, and of insuring that stability of flotation which was wanting in all floating docks then in use, as well as from their enormous cost. It then occurred to the author, who under the direction of Mr. Robert Stephenson had designed the machinery, and superintended the raising of the Britannia and Conway tunnel bridges, that a similar process might with advantage be applied to the docking of a vessel. The problem was simply to raise a given weight to a moderate height in the most rapid and economical manner; and there appeared to be no reason why such a vessel should not be dealt with in the same way as any other load. The weight actually lifted at the Britannia bridge, with only three presses, was equal to that of a vessel of 1800 tons.

In noticing the early history of graving docks, it was remarked that the expedients at first adopted continued in use in their original form, the principles involved having in no way been departed from; so that a modern first-class graving dock only differed from the earlier plans in design and details. The next was made to the docks at present in use, and the dimensions were given of a work of this kind recently completed at Portsmouth, which was sufficiently large for docking the 'Minotaur,' a vessel of 6621 tons. The inclined plane or slip had also received its share of improvement. In situations where the ground was swampy, it was observed that the slipway was peculiarly applicable for small vessels, on account of its economy, and that the hydraulic press had been used advantageously as a hauling power. But a graving dock of large dimensions was necessarily a costly work. It must be approachable by a deep channel, as well as having a depth adjacent to deepwater. In a gravelly soil, or in rock penetrated by fissures, the difficulties were sometimes nearly insurmountable. Doubtless the cost of these docks, and the impracticability of making them at all, in some situations, led to the use of floating docks. These were at first built of timber, of moderate size; and a description was given of a work of this kind in the harbour of Naples. The same principles were subsequently applied to docks of large dimensions, constructed of wrought-iron, and furnished with elaborate pumping machinery. This system attained considerable development in America, there being timber docks on this principle at New York, Charleston, Savannah, Mobile, New Orleans. The first of prominent press dock would be found in Mr. Stuart's 'Naval Dry Docks of the United States.'

Those at Portsmouth and Pensacola were so arranged that, after a vessel was placed on the pontoon, it might be hauled a short distance on its cradle, on bedways prepared for the purpose. The dimensions of that at Pensacola, which was completed in 1830, with the cost, were given. The floating sectional docks at San Francisco and at Philadelphia were next described. It was contended, that the use of floating docks was necessarily limited, not only by their enormous cost in construction and manipulation, but their liability to accident from mismanagement, of which instances were cited.

It was with a view of meeting, as far as possible, the objections to existing systems, that the author proposed the Hydraulic Lift Graving Dock as an efficient and economical substitute for the requirements of the Victoria (London) Docks. The works were ultimately undertaken by 'The Thames Graving Dock Company,' the site chosen being a bit of shallow water lying between the Victoria Docks and the Thames, and below the high-tide level of the river. This site admitted of a direct entrance from the docks, with a permanent water level, without the cost and delay of a special entrance from the river. The soil was a deep bed of bog and alluvial mud, on a substratum of gravel. The only excavation necessary was the lift pit, and its depth sufficed to the depth of water in the lift pit, which was 27 feet; over the remaining water space it was only 6 feet, which was the maximum draft of the pontoons. In the shallow-water space there were eight pontoon berths, separated by jetties, for workshops and access. They were all 60 feet wide, and from 300 feet to 400 feet long. The area of shallow water was 16 acres, or sufficient for floating 15 or 30 pontoons, which it was estimated was about the number that might be kept employed by the system. The general arrangement of the dock was such as to make it suitable for both repairs and for the regular operations—first, the direct raising of the weight on the lift; second, the transportation of the vessel to any convenient position for its repair on the pontoon. The lift was a direct mechanical appliance for raising the vessel by means of hydraulic presses. It consisted of two rows of cast-iron columns, each 6 feet in diameter, each 15 feet 2 inches in length, the columns being spaced 1 foot apart from the top of the columns. The lift was 60 feet, and the columns were 20 feet apart from the centre to centre, and were placed on each side of the lift pit. There were six columns in each row, giving a length of 310 feet to the dock; but, as vessels might hang on the ends, there was a practical working length of 350 feet. The columns were sunk in the usual manner, about three or four being fixed per week. When the requisite depth was attained, the base was filled with concrete, and covered with a layer of planks, to act as a cushion for the cast-iron seat on which the press rested. The columns supported no weight, but acted solely as guides for the cross-heads of the presses, which moved in slots, running from the top to the bottom of the columns. The lift pit was 10 feet wide and 10 feet high, and the column heads were 10 inches in diameter, having a length of stroke of 25 feet. The rams were solid, and each carried a boiler-plate cross-head 7 feet 6 inches long, thus extending 1 foot 9 inches beyond the column on each side. From the ends of the cross-head were suspended two iron girders, each 65 feet long, extending across the dock; then the block to the opposite side. There were thus sixteen pairs of suspended girders, forming a large wrought-iron platform or gridiron, which could be raised or lowered at pleasure, with a vessel upon it. The sectional area of each ram being 100 circular inches, a pressure of 2 tons per circular inch gave 300 tons as the lifting power of each press; or 6000 tons for the whole lift; but to find the available lifting power, it was necessary to deduct 630 tons, being the weight of the rams, cross-heads, chains, and girders, leaving 5780 tons for the pontoon and vessel. The water was forced into the presses immediately beneath the collar at the top, this being an accessible position, and it was therefore naturally selected for consideration. Stability was secured by arranging them in three groups; one group of sixteen presses occupying the upper part of the lift, the remaining eight presses on one side forming a second group, and the opposite eight constituting the third group. The presses in each group were all connected, so that the lift would be obtained as regards its individual presses, while the three groups were arranged so that their centres of action formed a tripod support, upon which the pontoon was seated. As any one point of the tripod might be raised or lowered, without regard to the other two, by the most simple manipulation, the pontoon could be either raised or lowered by the simplest lever, or any inclination could be given to it that was desired. Any pair of presses might be instantly cut off in the valve room, by means of a plug, even during the operation of lifting, without interrupting the process. It was stated that the raising of a vessel occupied about twenty-five minutes; and that during the severest cold, a few occasional strokes of the pump were sufficient to keep all in motion, and prevent congelation.

This lift was all that was required for raising or docking a vessel, and it was believed that it would be found more economical and convenient than any ordinary dock; but it would accommodate only a single vessel. The presses, by an indefinite number of vessels might be pressed afloat, whilst the most costly part of the system remained constantly available. The following was the arrangement adopted: An open pontoon, proportioned to the size of the vessel to be docked, was selected. Keel blocks and sliding hinge blocks adapted to the vessel formed part of the pontoon, which was placed on the cross girders and sunk with them to the bottom of the dock. The vessel was then brought between the columns, and moored securely over the
centre of the pontoon. By lifting the girders, the keel blocks were first brought to bear under the keel of the vessel. The side blocks were then hauled in, by chains laid for the purpose on each side of the dock and the girders and the pontoon, with the vessel upon it were then all raised by the presses clear of the water. The pontoon was provided with valves in the bottom, and thus emptied itself of water. The valves were closed and the pontoon lowered to the level of the water, but the pontoons, the vessel upon it remained afloat. Thus, in about thirty minutes, a vessel drawing 18 feet of water was left afloat in a shallow pontoon drawing only 4 feet or 6 feet, and might be taken into the shallow dock prepared for its reception. The details and dimensions of the seven pontoons at present in use were given. The cost of the lift complete and ready, including columns, presses, girders and pipes, had been £20,300; of the 50 H.P. condensing engine pumps, &c., £3800; and of the connecting pipes, &c., £1828. At the end of last year one thousand and fifty-five vessels had been lifted, of an aggregate tonnage of 713,390 tons, without a single casualty.

The advantages of the pontoon were then discussed, and certain proposed modifications of the system, showing the practicability of enlarging it to meet the requirements of vessels of any size, were described.

In conclusion the author considered the principal features of the system, its economy of first cost, by the short time required for its construction and erection, and in subsequent maintenance, by the simple and durable character of all its parts; its adaptability to almost any situation, especially in harbours or tideless seas, by which any area of shallow water could be rendered available as a dock for the largest vessels; its capability of almost indefinite extension, by the use of additional pontoons, or, as regarded the lift, by the addition of extra columns; its rapidity of manipulation with a small staff, by which even vessels in cargo could be docked, with freedom from all strain; and the convenient accessibility it afforded to all parts of a vessel, and especially in painting iron ships, their free exposure to light and air. These characteristics were very strong points, which others might be inclined to. Thus it is evident the system afforded ready means, by the construction of a shallow canal, of transporting the largest vessels in cargo, either across an isthmus or over shallow rivers, and of removing vessels of war inland, either for their protection or for their employment as a means of internal defence; or for the laying up under shelter, or building or navigating vessels in any shallow-water space, rendering unnecessary the large area of floating dock accommodation now required, by which a considerable portion of the enormous expenditure which characterised such works might be economised.

NEW CHURCH, THORNCLIFFE, NEAR SHEFFIELD.

(With an engraving.)

This church is of early Gothic design of the French development. It consists of nave, transepts (now used as vestries), and tower at its west end, where is also the principal entrance. The height to the wall-plate of nave is 20 feet, to ridge of nave 44 feet, and to ridge of transept 37 feet. The external dimensions of the plan are 92 feet long, by 86 feet wide; across transept the nave is 36 feet wide; the tower is 68 feet high, to which it is intended at some future period to add a spire. There are galleries over the vestries and lobby in tower; sitting is provided for 333 persons on the ground floor, and in the galleries for 188, making a total of 521. The entire cost was £2650.

The windows and moldings of doors are very bold and simple. At the east end is a large square apse, in which is placed the communion table. The church is built for Messrs. Newton, Chambers, and Co., by whom the heating apparatus is provided. Their apparatus is found to be very efficient, and is very highly recommended by the architects. The walls are 2 feet thick, those of tower 2 ft. 6 in. In the tower are stone clock and belfry loft. The walls are built of range work of native stone; the shafts in doors, &c., are red Mansfield stone: the roof is covered with slates with Delahoe bands; the internal fittings are picked red deal shield and varnished; the roof is boarded to collar, in which are ventilators communicating with an exhausting flue in tower. The floor of the church is laid with Godwin's encaustic tiles.

The church occupies a site on the top of the hill, commanding a very extensive prospect, and has been erected almost entirely by the munificence of Messrs. Newton, Chambers, and Co., of the Thorncliffe Iron Works, from the designs and under the superintendence of Messrs. Wilson and Wilcox, of London and Bath, architects. The builders were, Mr. Robinson of Barnsley, mason; Mr. Smith, of Hemingfield, carpenter and joiner; Messrs. Leadbeater and Brown for the other trades. Mr. Sykes was Clerk of Works. There have been very few extra.

THE INDIAN TRAMWAY COMPANY.

The Railway system of India is one of the most important in the world, and yet it is the weakest, since it everywhere seeks to meet the commercial requirements of immense masses of population by long main lines. These, of necessity, are constructed with reference to the political needs of the Government, as much as with regard to the commercial wants of the people. And even, were it not so, it is evident that the farther a main line of railway penetrates into a country like India, the greater is its inability to meet the enormous traffic which will seek, by its means, an easy and speedy mode of transport to the metropolis. That main lines of railway like that which links together two such cities as Calcutta and Delhi, are altogether unable to meet the demands made upon them, the public have not now to learn. Trains are filled to the very doors of the railways, and wonder at the quantity of produce enumerating almost every station beyond Burdwan. So great, indeed, is the pressure on the resources of the railways, that the construction of a double line throughout its length is a mere question of time, and one upon which there is no division of opinion. But we require a similar system for the shorter and more local traffic interneighbouring districts. The external commerce of the country will, to a certain extent, look after itself, but the internal trade is yet in its infancy. The greatest efforts are made to provide for a yearly increasing export trade, whilst little or nothing is doing to break down the barriers between provinces and province, and to unite all the Political Divisions in a trading intercourse between the various nationalities of India.

The Government is at a loss how to meet this want. It cannot make roads fast enough, and besides this, its first duty is to make the districts easily accessible from the metropolis, rather than easily accessible to each other. There are, however, two companies in the field, who promise to do this last work more effectually than any Government could do. These are the Indian Branch Railway Company and the Indian Tramway Company. We have before us the Proceedings of the Fourth Annual General Meeting of this last company; at this meeting the report for the year 1868 was read.

The proceedings, which are accompanied by an excellent map, have reference to the line between Arcoum and Conjeeveram, in the Madras Presidency. This line was opened for 162 miles on the 8th May, 1865, and for the whole distance of a little over 18 miles on the 1st August. Of the total length, 144 miles were constructed in a Government road, whilst 4 miles were carried across country. The total cost of the line was £75,000. Now, taking into consideration the whole of the circumstances of a railway scheme of this nature, and remembering that a short line is almost as expensive as a long one, we find the line between Arcoum and Conjeeveram has established the following facts:—

"The railway had been constructed, not only within the capital, but within the mileage cost originally assumed, and the returns already exceeded the highest per-centage ever obtained on any Colonial line during the first few months. A weekly mileage return of £9 would pay 5 per cent., and the line was earning at starting about £7 of that sum, with a constantly increasing trade. The company have already established the important fact that cheap light lines of railway could be made in India, at a total cost for all expenses, including engines and rolling-stock, of £4000 per mile, capable of transporting loads of 100 tons at 35 miles an hour, at a very moderate cost for fuel, with working expenses commencing at £65 per mile, which have fallen to £25 per mile, and at its earliest opening paying a dividend of 4 per cent."

This should show the Government the value of these subsidiary companies, and induce it to grant them more liberal and favourable terms for the construction of lines of light railways, which shall foster and develop trade between province and province.—Hulken.
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL

119

THE COUNTY LUNATIC ASYLUM, CLARE, IRELAND.

The site of this building consists of 40 acres of land within a mile of Ennis, on the Gort-road, at the northern side of the town. The building faces the south, towards which the ground slopes gently. The character of the building is simple and bold. There is a central tower of good outline; the windows generally are circular-headed, have plain square architraves surrounding them, stopped square arches.

If consists of a front centre building containing the official residences and public rooms, two wing buildings for the patients, with two airy courts at the rear of each, and a rear centre building containing the dining-hall, kitchen, laundry, and other offices. The front and rear centre buildings are connected by covered corridors.

The extreme length is 600 feet, of which the front centre building occupies 80 feet, the wing buildings extend 200 feet at each side, where they return about 100 feet, the remainder of the length being occupied by the infirmaries. The extreme depth of the building at the centre is 350 feet, and embraces the kitchen and laundry offices, with the hall and front centre buildings. The day-rooms average in size 40 feet by 24 feet. The dining and recreation hall is 58 feet by 30 feet, and the height of two stories, with an open roof.

A series of day-rooms, on the ground-floor, dormitories on the upper floor, and passage of moderate width, have been adopted. It is thought, with the sanction of the Board of Control, that this arrangement in separating the day and night accommodation of the patients, and otherwise assimilating their circumstances to those of ordinary life, is preferable to the usual corridor, or ward system, as it is termed. The infirmary buildings are placed at the extreme ends of the wings. At the rear, connected with the airy courts of the male wing, is a working ground, with suitable workshops opening to the same.

The front centre building, which projects about 50 feet from the wings, is placed at a higher level, and has a terrace front, admits of a basement, in which the kitchens and offices for physical and medical examinations are placed. The chapel, which has a vestry and separate entrance for male and female patients, is situated on the first-floor at the rear of the front centre building. The ground floors of the wings are chiefly appropriated for day-rooms and single rooms. The day-rooms nearest to the centre, at each side, are for the tranquil patients; those more distant for the refer patients. The passageways are placed next the dormitories, with glazed doors between, and are in the proportion of one attendant to thirteen patients on an average. The whole number of patients for which accommodation is provided is 260; and 25 ft. superficial are provided in the day-rooms for each patient, and 30 ft. superficial in the dormitories, the ceilings being 12 ft. in height.

Infirmary accommodation is provided for one-twelfth of the whole number of patients, and single rooms in the proportion of 30 per cent. Two staircases with solid walls are provided for each wing. The kitchen, 30 ft. by 30 ft., adjoins a scullery and a boiler-house. The farm offices,eward's house, &c, to comprise a separate detached block of buildings.

The walls are built of the local light-blue limestone, and the outside walls are lined with brick of the locality, the quoins and dressings neatly chiselled. Sandstone is used for staircases and door-sills; and, as a check to the spread of fire, should such ever occur, references to others, are set in the corridors at intervals of about 40 ft. The cross walls which there occur are carried up to the underside of the slating. The plates for the floors throughout are carried on stone corbels, and wood battens are very sparingly, if at all used. The roofs of the dining-hall, kitchen, and laundry are formed with open timber framing, and the rooms and verandas, balconies in 1st, and the closets, lavatories, and baths are formed of Valencia slate. Almost throughout the entire building the interior is plastered. The windows have wood sashes, except those to the single rooms for refractory patients, which are of wrought-iron. The ventilation is to be effected by flues from each room, carried into horizontal galvanized iron air-trunks in the roofs, thence into the side towers, in each of which a shaft is carried up, with a fire-place at bottom to ensure an upward current. These buildings were chiefly designed by Mr. W. Fogerty, architect, of Dublin, and the building completed under the joint superintendence of Mr. J. Fogerty, of Limerick, and Mr. A. C. Adair, the county surveyor of Clare.

The amount of the present contract, exclusive of boundary walls, gate and other lodges, farm offices, baths, water-closets, and engineering works, is about £29,000; but it is estimated that the total cost will amount to £30,000. Mr. Michael Macle, of Dublin, is the contractor, and Mr. Fitzgerald Clerk of the works.

John Dixon.—John Dixon, of Darlington, civil engineer, died 10th October, 1865. He was the oldest railway engineer of the day, having been the resident engineer on the Stockton and Darlington Railway, under the celebrated George Stephenson when he made his first attempt at railway engineering; and it is significant of the after excellence of his work that it is still a matter of great pride and interest to the subjects of the kingdom, Mr. Dixon should return to Darlington to end his days as consulting engineer to the Stockton and Darlington Railway Company, in whose service he died, having been from 1820 to 1865 actively engaged in the construction and management of railways. He was born at Cockfield, near Raby Castle, Durham; his father was a farmer, and as well as a land surveyor and colliery engineer; and from him he received that sound practical and scientific knowledge which was of special service to him in after life. It may be noticed that his grandfather's brother was selected by the Royal Society to go to Bencoolen, in Sumatra, to take observations of the transit of Venus across the east of 1761, and assisted at the transit of Venus at the Island of Huanfesto, near the North Cape, in 1769. When the question of making a communication between the Durham collieries and a port of shipment was under discussion, Mr. John Dixon was able to give some very useful information, having, in his possession plans and sections which his grandfather, George Dixon, a man of scientific eminence in the county, had prepared about the year 1769, when he proposed canal communications with the collieries. When George Stephenson was consulted as to the construction of the Stockton and Darlington Railway, Mr. Dixon was engaged to show him the plans and levels in his possession, and to accompany him in making the surveys which resulted in the line which lasted through life. During the construction of that line Mr. Dixon remained at Darlington as Mr. Stephenson's resident engineer; and it was during this period that Mr. Stephenson's only son, the late Robert Stephenson, received from Mr. Dixon his first instruction in taking levels and surveys, and in setting out railway works. Mr. Dixon was George Stephenson's resident engineer on the Canterbury and Whitable Railway, on which was constructed the first railway tunnel. He was resident engineer at the Manchester end of the Liverpool and Manchester Railway; and remained for some years after its completion in charge of the maintenance of the way and works, and of the locomotives, a post of great responsibility, there being at that time no experience to guide engineers as to the relative durability of the different working parts of locomotive engines, or of the best modes of repair. After constructing the Birmingham and Derby, the Chester and Birkenhead, and the Carlisle and Whitehaven railways, he returned to Darlington, where he remained till his death. Mr. Dixon might perhaps have attained higher eminence, and have been more known to the public generally, had he been a man of more ambition; but his retiring nature led him at all times to shun publicity.

Alan Stevenson.—Alan, eldest son of the late Robert Stevenson, civil engineer, and designer of the Bell Rock Lighthouse, was born at Edinburgh in 1807. He was educated at the High School and University; a young man of great distinction he himself, and took the then somewhat unusual degree of Master of Arts, and obtained under Leslie the Fellows Prize for excellence as an advanced student of Natural Philosophy. He afterwards studied in England, and received the degree of Bachelor of Laws from the University of Glasgow.
His own wish was to study for the Church, but he gave it up for his father's profession, in which he soon made himself a name. Though obliged by illness to retire from work when in the fulness of his years and powers, the services he performed as Engineer in the government services of various countries, and particularly those in America, as well as in Brazil and Peru, are not to be forgotten. The portico, being groups of children and various religious emblems, by M. Cordier and M. Carrier Belleuse. On the summit of the pediment is a cross, supported by two angels, sitting in their crown of thorns, by M. Schroeder. These exteriors of the wings and of the temple, which are carved in stone, ture, are executed in the style of the Renaissance, the figures being sculptured in stone, and three paintings, besides the metal doors; there are, moreover, several minor decorative works, such as bronze candelabra at the entrance, and ornamental water-sprouts. The interior will be decorated in keeping with the exterior, but the former is not in the same degree of advancement as the latter. The temple is expected to be complete in the cold weather, and the remaining statues in marble, one of Mdlle. Mars, by M. Jules Thomas, and the other of Mdlle. Rachel, by M. Duret, have just been placed upon socles on each side of the vestibule which leads to the noble staircase lately constructed in the Théâtre Francais. The theatre or salon of the same theatre is richly decorated with bas-relief and statues, and it is connected with a gallery in which are busts of a large number of the most celebrated dramatic authors and actors. The decorations of the former are new; the gallery has been in existence for a long period, but its contents are being constantly augmented.

**Introduction of Gas into India.**—The introduction of gas into the city of the Nizam of Arcot, is of the greatest importance. In a place where the electric wires are regarded with the greatest distrust, and where the prospect of a railway engineer's appearance is discussed on deep religious and political grounds, one might well have supposed that the preparation of so mysterious an agent as gas, almost at the very gates of Hyderabad, would have excited the deepest suspicion. In the hands with which it is now placed, however, there may be one, a house in Chudderghat is now brilliantly illuminated with gas; and the experiment, tried at the risk and expense of one individual, has proved so successful, as to induce the hope that in a short time oil and candles will be entirely superseded in the principal houses of Chudderghat. The gas, which is prepared either from common coal or from seeds containing a fair percentage of oily matter (especially the castor-oil seed, of which one pound yields over ten cubic feet of gas), appears free from any noxious properties, and furnishes a pure and brilliant light, at a very trifling expense. Though, as usual in such cases of private enterprise, has not all the support of the government, yet the manufacture would, if properly supported, be able to form part of a splendid tomb of the Antonine period. On the 22nd ult. the Roman Pontifical Academy of Archaeology met under the presidency of Prof. Salvatore Betti, Commander Visconti, perpetual secretary, furnished details of the excavations now carried on at the Palazzo, at the expense of the Pope and Commander Constantin Beld, minister of commerce and public works. All accounts of considerable dimensions have been brought to light, ornamented with paintings, stucco-work, and marble. He also described the investigations now continuing in the neighborhood of Sutia. The Rev. Felice Prolisi, rector of the Pontifical Seminary and secretary of the Commission of Sacred Archæology, also gave an interesting account of the excavations which have taken place in the Catacombs of Rome, from November 1860, to May 1865.

**Railway Carriages.**—It appears that new carriages have been built in Milan to run upon the long line of railway from Siena to Brindisi, which is to convey the Indian mails and travellers from England. Some of these carriages are adapted for families or parties of passengers. They are provided with very extensive carriages, and divided into three compartments, communicating by sliding doors. There is one room for servants, the sitting-room with four convenient sofas, upon each of which one person can sleep, a bed-room with a bed for two persons, washing apparatus, &c., while in the daytime the travellers can walk up and down through the three compartments.
THE LATE MR. DAVID ELDER, ENGINEER.*

By James R. Napier.

The history of so remarkable a man as David Elder must be interesting to many on account of his connection with works which have made Glasgow and the Clyde notable, and given to his employment a name which is known over the engineering world. A respect for his memory, and the great benefits received from his advice and experience, induced the author, in the absence of those older and more able for the duty, to make the attempt. The author is indebted to an old friend of Mr. Elder's family for an account of his early life, of which he has availed himself.

David Elder was born at Little Seagie, near Kilmarnock, in January, 1785. His father was an Anti-Burgher elder, and in consequence of the religious strife in the district, he was deprived of such education as the parish school of Orwell then afforded, a loss he ever after regretted.

About the age of 15 he was put to learn his father's business, that of a countrywright, and at this period he repaired parts of Craigie Mill, at which he was occasionally employed, afforded him an early opportunity of studying mill work. The intermittent noise of this mill, which had wooden cogs and runges, and a flat bar for the axle of the trundle, attracted his attention, and taught him his first lessons in wheel work and gearing, which he afterwards practiced so successfully that as his studies were not in accordance with his father's wishes, he resorted to Little Seagie Glen to study Simeon's Euclid, and a work on algebra translated from the French—which he had traveled 18 miles to get possession of; and when his seniors would be devoutly employed at a tent-preaching, David Elder would be found studying hydraulics before an old waterwheel in the neighbourhood, or the architecture of some old castle.

On one of these occasions he found out a simple approximate rule for estimating the weight of water in pipes. A tin can of his mother's, which happened to be three inches diameter and four inches deep, he found held as he might a pound of water; and as the square of the diameter multiplied by the length was equal to 36, so David Elder settled that a pipe a yard long held as many pounds of water as there were inches in the square of its diameter. It was sufficiently accurate for the most of his requirements, and very easily remembered, and he constantly used it.

In 1814 he went to Edinburgh, and was employed at Charlotte-square buildings, and borrowed such books as he could get to study, from a bookstall in the Luckenbooths in the High-street, for a penny a night.

While repairing a mill about this period, at some very inaccessible part of which he had been working for two or three days and nights on account of his dirty habit, he was lifted while in the air, and was therefore very tired, he was so disgusted, when giving the last turn, as it were, to one of the nuts, to find that the thread of the screw had stripped, and rendered all his labours useless, that he vowed if ever he had a chance he would make bolts and nuts whose threads would never strip.

In 1814 we find him married, and employed by Messrs. J. Clark and Co. of Paisley, and afterwards superintending the building of their factory at Mile-end, Glasgow. He was afterwards employed by Mr. James Dunlop, in the erection of Broomwood Mill. One of the walls of this building having got bent, he contrived a large truss of timber all the length of the building, laid on one of the floors, and, by means of bolts passing through the frame and walls, attempted, by screwing up the nuts, to straighten the building. He succeeded merely in compressing the timber. This lesson he never forgot.

About the year 1820 he appears to have made a business connection which was unsatisfactory to himself, and in 1821 he became manager of Mr. Robert Napier's engineering works, then at Cambchie.

A circumstance which induced his employer to commence and prosecute the manufacture of marine engines, and which need not here be mentioned, gave Mr. Elder an opportunity of putting in practice much of the machinery the want of which had previously caused him so much discomfort, and of originating many others.

About the year 1822, his employer had contracted for his first marine engine for a steamer called the Leven, to ply between Glasgow and Dumfries. The few tools at Mr. Elder's disposal at this period may surprise many. A few 10 inch to 14 inch turning lathes, with wooden shears and small narrow pulleys and belts constantly slipping, a rude horizontal boring mill, and a smaller vertical boring machine, constituted the greater part of the stock. With these he succeeded in making a piece of work to which he often afterwards referred with pride. Many of the improvements of the marine engine were first introduced by him in this one. He faithfully fulfilled his vow about the nuts which had so annoyed him at an earlier period, by making them 1 1/2 times the diameter of the bolt,—a practice which, however unnecessary such dimensions may be considered to be now, with all the advantages which the accurately cut screws Mr. Whitworth's lathes have since produced, was then a genuine improvement. In the Leven's engine also he first introduced his improvements in the air-pump, condenser, and slide valve, which shall be presently noticed. His first difficulty, however, was with the wrought, the old millwrights of the period, whose idea of good accurate workmanship was so very different from his own, that he preferred always to work with good cartwrights or house-joiners, and selected the most intelligent of these to superintend the different departments, and for an important tool, believing that they would carry their ideas of close-fitting joints of wooden structures along with them, when they would be called upon to construct iron ones. In this belief he was not disappointed, and in order to assist in working it out he contrived many tools which would execute the work better, and make him independent of the services of those who rebelled against his system, and would have compelled him to adopt theirs. One of these tools is the parent of all the paring machines. It was for many years the only tool of the kind in the country, and performed work with an expedition and accuracy which no hands could execute, and which, at the date of its construction (1833) did the work of those legal hands, as they called themselves, who had then combined to stop the works by their Union. They called it the "devil." It was the greatest "nob" ever entered the establishment, and was designed principally for finishing the straps of the connecting rods and side rods; but, like every tool which has ever been constructed, it got other work to execute, and was therefore seldom idle, and led to works being undertaken which were formerly unhought
of, on account of the difficulty and expense attending their execution. He afterwards designed a much larger tool on the same principle.

A simple addition to an ordinary turning-lathe secured the greatest strength with the smallest quantity of material in his side-rods, crossheads, &c.

The link of his punching machine, or piercing engine, may be instanced as one among many of his improvements in tools. In this the loss by friction is reduced to a minimum when the pressure is greatest.

His knowledge of the forces which acted on the different parts of a machine, appeared as a sort of instinct, and for which he provided in the most scientific manner. He prevented the possibility of any work being performed by the joints of the frames, and so economised the available power of the engine, by having every joint metal to metal, and as much bearing surface and as closely fitted as it was in the power of the men and tools at the time to execute; and in the bolts and nuts which fastened these frames, each and all of them were so turned and fitted by draw-filing, and the seats for the bolt heads and nuts made so fair, that every thing was bearing iron to iron. The neglect of this sound mechanical principle in some of the works of competing engineers, led to their rapid deterioration. The perfection of modern tools has made these shaky works much less frequent than formerly.

The trouble which the loss of vacuum in the condenser often gave to other engineers, from leakage round the main centre, he avoided entirely, by the simple expedient of casting a tube through the condenser, into which the main centre was driven; and also by the greater rigidity he gave to the main centre by not reducing it in the middle of its length, as others had done. In order that this main centre should be thoroughly fixed and rigid under the greatest strain that could possibly come upon it, he invented a tool for boring the tube. This tool was self-acting in its feeding motion, and bored itself a conical hole, so that when the main centre was prepared, and thoroughly driven home by the force of large rams suspended from the ceiling of the fitting-shop, it was immovably fixed. This tool for boring conical holes he used on many occasions afterwards. The main centre itself, notwithstanding this care in its fitting, was prevented from turning in the tube by three keys driven in above it, and none below, as some were wont to do, thereby taking all the stress due to the weight of the levers, &c. &c., off the keys.

The first double engine he designed was for the Eclipse, a vessel which sailed between Glasgow and Belfast. At the starting of this vessel, in July 1826, he was nearly killed. The hot well was open above, as was then usual, the one engine had formed the vacuum, and the other had got hot, sending the hot water and steam through the hot well into the engine-room, and severely scalding Mr. Elder, who was the last to get out of it. This accident led him to raise and close the top of the hot well, and lead a waste pipe to the outside of the ship, as is now universally done.

He economised to the utmost the power required to work the long D valve which he commonly used, and greatly reduced the cost of keeping it in efficient order by a skilful disposition of the packing. He lengthened the valve upwards and downwards beyond the face, so as to get the packing immediately opposite the port, thereby reducing the pressure both upon the valve face and packing. Some of the old arrangements of packing are to be seen in the engine of Boulton and Watt, and others, in Tredgold's work on the Steam Engine, as well as the old arrangement of air-pumps, which Mr. Elder made efficient by the simple expen
dient of lowering the working barrel of the pump to within a short distance of the bottom of the well. However self-evident such an arrangement may appear now, or when pointed out, a different practice was followed in the marine engines of the period preceding the commencement of Mr. Elder's career.

His early practice of what modern engineers call cushioning the steam, by the cover which he invariably put on the aduction side of the valve, so that the steam left in the ends of the cylinder, in the ports, and passages would, at the end of the stroke, be up to the pressure of the boiler at the beginning of the next stroke, showed that he was as well acquainted with the practical advantages of a system which he had reasoned in his own way to be true, as Dr. Rankine, our worthy Professor of Engineering, is, with his theoretical deductions on the same subject. He was, at the same time, quite alive to the effect this cover on the valve would have on the steam escaping from the cylinder to the condenser, and to the necessity of having larger ports to let the steam out of the cylinder than to let it in owing to the reduced pressure after it had done its work. When others, therefore, were working with small ports, Mr. Elder had gained a decided advantage in the greater power and efficiency which his arrangement produced. The author believes he was the first to apply expansion valves to steamers, in the engine of the Berecnice, built for the Honourable the East India Company,
drawings of which will be found in Tweedgold. A comparison of the performances of this vessel with a sister ship, built in London, showed very favourably for the economy and efficiency of the Clyde ship.

An accident to one of the Dundee and London steamers, the Perth, about the year 1832, when off the north of England, on her voyage to London, arising as he imagined from water getting into the cylinder from the condenser, caused him to make an alteration in the position of the snifter valve, which made it nearly impossible for such an accident to happen again from the same cause. Although these snifter valves had been originally placed on the condensers of land engines by Boulton and Watt, in their marine engines, they were attached to the well of the air pipe. He believed that the snifter valve had not shut after the engine was blown through at starting, that the air which entered through it prevented the foot valve from opening. The condenser would then be filling with water, till it got above the lower edge of the lower port of the cylinder, into which it would enter, and then the whole power of the engine would spend itself in breaking its weakest parts. When these valves are placed in direct connection with the condenser, any leakage of air through them increases the pressure in the condenser, reduces the supply of water, and shows itself on the vacuum gauge and speed of the engine.

From his own early experiments and later experience of wooden structures, he took care, in giving the builders of the wooden ships the plans and directions for the framing and fastening of the engine keel-joins, paddle beams, and all that affected the rigid fastenings of his engines to the ships, that these parts should be thoroughly well secured; and was wont to boast regarding the Atlantic steamer, British Queen, that whatever else of the vessel would break up, if she happened to get wrecked, this part of his, connected with the engine, would stick together; as it certainly did, to the great disgust of those who afterwards purchased the vessel on the Continent, to break her up. It certainly cannot be said that such caution was unnecessary either for the machinery or the engines. Nearly all the English vessels on the Atlantic line had their engine frames broken, probably from the weakness and twisting of the vessel; and the fate of the President will, by those who saw her deformed state, and the means taken to hide it before her departure on her last voyage, be ascribed to a want of that anxious caution and forethought on the part of her constructors which was so thoroughly engrained in Mr. Elder's character. For similar reasons, he continued the sole plate under the cylinder, and was the first (in the author's belief) to do so.

The fitting of the malleable iron columns to the sole plate and entablature of H.L. The columns of High Level may be examined as an example of his care and caution. One of his maxims was to make the machinery depend on itself for its rigidity, and not at all upon the vessel. His cast iron Gothic frames, so well known for their elegance and simplicity, could be well secured to the sole plates, and to each other, by flanges and bolts of any dimensions; and the frames also could be made to fit each other, so that, let the ship roll, and pitch, and perhaps twist, as she might, the engine was not to twist; it was to be affected in the least degree possible by the probable twisting of the vessel. In order to secure as far as possible the same advantages for the malleable iron frames of the Thunderbolts as for the cast iron, he constructed a large template frame, having the holes for the eight columns carefully bored in it. When this was laid across the two engines in the fitting-shop, the boring-bar was fitted, and conical holes bored through all the extent of the casting for the lower bearing of the columns. The bearings in the entablature were bored from the same template. The columns were turned at top and bottom, to fit these holes throughout, and draw-filed afterwards, so that there could be no possibility of motion. The entablature dropped easily over the heads of the columns, and by the depth of the sockets below, and of the entablature above, the frame was rigid, almost without cross-bracing.

About the year 1840, our Government was induced to contract with Mr. Robert Napier for the machinery of two of their war vessels—the Vesuvius and Stromboli. In March 1843, the House of Commons ordered a return of the cost of repairs, &c., of a number of steamers, including these. From this return, which was printed in June 1843, the author then arranged the data as in the table, and made the deductions there noted, as it shows more clearly and forcibly than anything that can be said on the subject, that the care Mr. Elder bestowed on all his works was in the highest degree economical to the country, and ought to have made his employer the chief of Government contractors, and put the Clyde above all competitors. It is here reproduced. It shows, moreover, as applied to mechanics that which many have to learn in regard to other matters, that the best is the cheapest.

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<th>Seaward.</th>
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<td>Days under repair</td>
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<td>Time of commission</td>
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<td>£ 19/8</td>
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Note.—The chief engineers and captains of the Vesuvius and Stromboli can testify that neither of these vessels were ever laid up for a single day for repairs of machinery. The repairs of the Vesuvius were for repairing carpenter work, damaged at Acre during a storm; and the Stromboli's, time for enlarging and making new coal-bunkers.

Mr. Elder's ideas of an economical marine boiler are embodied in those five-boilers of the British and North American Mail Company's steamers, the Cunard line, as it is commonly called. High and roomy furnaces, so that the gases may be as thoroughly mixed, and their combustion as perfect as the dimensions of the boiler would admit of, before getting cooled against the roof of the furnace, and thereby rendered incomprehensible, with water spaces so large and accessible that every part can be repaired in the vessel.

When Mr. Robert Napier extended his business so as to embrace iron shipbuilding, Mr. Elder, believing that it was impossible to make sound work with the ordinary process of rivetting long hot bolts, had the keel plates of the Vanguard, the first iron steamer launched from the new shipbuilding establishment, bored instead of being punched, and the rivets made of soft charcoal iron, turned, carefully fitted to their holes, and rivetted cold. This was in the year 1842. Those who know how important sound workmanship is in those parts of the vessel which are so long inaccessible, and often so heavily stressed, will...
appreciate Mr. Elder's foresight and caution—a caution which the inexperienced youth who shortly after took charge of the shipbuilding had much need to learn.

Mr. Elder's ideas of the position of roof-lights for sheds or workshops, should be practised more often than they are. These lights are often placed near the ridge, the one light showing through the other, and little light upon the floor or the work on it. When the light is lower down the roof, near the furrow, the whole is better lighted.

His love of music, and early acquaintance with a celebrated organ-builder, led him to construct an organ for his own use. He afterwards erected one for his employer at Shandon, and as Mr. Elder's connection with Mr. Robert Napier was a happy one for himself, and a fortunate one for Mr. Napier and his family. When, some years ago, he ceased to be actively employed by the firm of R. Napier and Son, it was a very great grief to himself, and an irreparable loss to the author. He died on the 7th Feb., 1866, in the 82nd year of his age.

**DR. EDMUNDS' SYSTEM OF VENTILATION.**

*By Dr. J. M. Barry.*

My object in bringing Dr. Edmunds' system of ventilation under the notice of this society, is, first, because I have experienced its utility in preserving life and promoting health on board the ships of her Majesty's Emigration Commissioners; and, secondly, because I believe, with very little alteration, the apparatus can be adapted to ventilating the crowded dwellings of the poor, the ill-ventilated rooms inhabited by whom do not materially differ from the confined space allotted to emigrants on board ships during their transit across the pathless deep. With respect to the necessity existing for a better system of ventilation on board ships than any hitherto devised, we have only to refer to the frightful mortality in crowded passenger ships, arising from typhus, cholera, and dysentery. In the ships of her Majesty's Commissioners, in whose service I hold the office of superintendent, the average mortality during the most unfavourable seasons never exceeded two per cent.

Last year the system of ventilation I am about bringing under your notice was introduced into the service. Some of the ships have accomplished the passage without the loss of a life, many of them being altogether free from fever, dysentery, or diarrhoea, the principal sources of mortality at sea. Another satisfactory result is the reduction of infantile mortality.

In some Australian passenger ships I could mention, one-third of the children under five years have died. In the Commissioners' ships fitted with Dr. Edmunds' apparatus, worked by a steam jet, the results have been truly gratifying, some of the vessels—the General Caulfield, for instance—not losing any children. The system has been introduced into the Royal Navy; and while the mortality in the mercantile marine is three times greater than in the Navy, the mortality in her Majesty's ships fitted with Dr. Edmunds' system is much less, while the diminished sick list amply testifies to the better sanitary condition of the sailor's dwelling.

To illustrate the necessity that exists for improving ventilation in ships, and to preserve them from premature decay, I may refer to the observations of eminent writers on ship-building. Murray remarks that the means at our command for the purpose of preserving timber from premature decay may be summed up in two words—seasoning and ventilation—thorough drying of the timber on shore, when practicable; but by all means good ventilation on board. If these well-known and universally approved principles were properly carried out, we should hear but little of rotten gunboats, or hasty repairs to frigates after a first commission. What is most urgently required is, that there shall be as little stagnation of air as possible. However well seasoned and dry the timber may be when a vessel is launched, it will rapidly absorb moisture from the damp atmosphere of the hold, unless evaporation from its surface be kept up by a forced circulation of air. The beneficial effects of Dr. Hales' system of ventilation were evidenced by the fact, that from 1753, when it was first employed in the old Prince, to 1798, when the use of it was discontinued, the durability of ships was materially improved, as well as the health of the crews of those ships to which it was applied, especially transports.

The Earl of Halifax, in a letter to Dr. Hales, stated that the mortality of the ships on the coast of Nova Scotia which were not ventilated was, in comparison with those which were, as twelve to one. Dr. Hales proposed to keep up a circulation of air with windmills and air pumps. Mr. Farkins followed his system, substituting fans.

But what is most urgently required has not yet been practically realised—the producing a constant disturbing force on the

* Read before the Royal Dublin Society.
lower part of the hold, which should give motion to the foul air that has a natural tendency to lodge there, while suitable means are, at the same time, in operation for carrying it off, and supplying its place by the introduction of pure air. The constant operation of some means to produce this effect is necessary for the preservation of ships, the health of the crew, and the ship's store.

The introduction of pure and dry air into the hold is requisite to carry off the humi particles which adhere to the interior of a ship, and excite the latent elements of decay which, under circumstances favorable to their development, are soon apparent.

Fitcham, in his "Outlines of Ship-Building," remarks that it is in the hold of a ship, more than in any other part, that the destructive effects of the atmosphere are most apparent. The air, rich from the decomposition of animal and vegetable substances which fall into the hold, or accumulate from the defective manner of stowing ships. The want of proper ventilation will produce the most serious results to the health of the crew and the condition of the ship.

To accomplish what is desired, a system of ventilation is needed which will ensure a pure atmosphere in every part of the hold, and between the decks. In order to prevent the destructive effects of air, heat, and moisture, and to produce thorough ventilation, some disturbing force should be employed. It being thus evident that the best quality system of ventilation must be a subject, conceive that an efficient system of ship ventilation is necessary for the preservation of ships from decay by dry rot, and as a means for preserving the health and promoting the comfort of passengers and crews; for as damp and insufficient ventilation cause the destruction of the ship, so they prove equally fatal to the health of the passengers and crew. To this end, various modes of ventilation are employed, and an effective remedy can be found for dry rot by removing its causes, by the same means will the ship also be rendered healthy. The inventor of the system of ventilation which I now submit for your consideration, I think, accomplished what has been so long desired.

To Edmonds, Staff-Surgeon in the Royal Navy, has had his attention strongly directed towards the subject of ventilation by painful experience of disease and discomfort arising from the insufficient and uncertain measures usually adopted to lessen the stagnation of air in the close and confined decks of vessels of war. The construction of a ship, which is often considered to be the cause of many obstacles to free ventilation, in Dr. Edmonds' opinion, in reality offers facilities, which are now for the first time made available by his invention. The important object is attained by means of a novel system of air-shafts and channels, through means of which the perfect ventilation of the ship's timber and membranes of exhaustion is secured. It is well known that dry rot, or decay, missnamed dry rot, is caused by the dampness of the timber surfaces forming principally the sides of the openings or timber spaces, which are close channels leading up from the bilges at the bottom of the hold; these have a vent in the between-decks, and it is for the purpose of their ventilation, to prevent decay or dry rot in the timbers, that they are left open; otherwise, but for so important an object, such a source of foul smells, malaria, and consequent disease, would never have been allowed so long to pollute and poison the air of a confined space in which so many have to live and breathe.

It would be a parallel case if persons on shore inhabited a crowded apartment, into which the foul air from a damp underground cellar, with drausis running through, had vent by numerous open channels; but the passive circulation which takes place is insufficient for the purpose intended. The openings are usually in a dry state, and any timber employed in the ship's framework, if not well seasoned, is sure to decay. The premature decay of the gunboats, hastily built during the Russian war, is conclusive evidence of this. By the first part of the new system the operation of these openings or channels is reversed; they are converted, from their present action of fouling the air, into the most efficient means for ventilation. The ventilation is brought about by making them all branch air-channels of one large air-shaft on each side of the ship, which being led into the funnel in steamers, or into hollow iron masts or tube and cowl ventilators in sailing vessels, a constant updraught is created through them, up from the bilges where decay would generally prevail, even carrying all their foul contents into the open air, preventing contamination from the bilges and hold by creating a constant current of air flowing through the timber spaces. The timbers will be effectively ventilated, and dry rot prevented. Probably, even if the ship were built of unseasoned timber, all endemic causes of disease existing in the ship, and which usually cause, or at least promote, the ravages of fevers in tropical climates, will be removed by this plan. In most cases of malignant fevers occurring on board ships in the Royal Navy, the bilges and timber spaces have been found choked with decaying matter; and there can be no doubt that in the mercantile marine similar causes prevail, with leakage from cargo superadded.

In the reports of the Social Science Association, it is stated that, notwithstanding the great advantages of selection, diet, and discipline enjoyed by the royal navy, the rate of mortality is much higher than in all other classes of life, from the healthful life led by sailors, and receiving food in the open air, that many causes of disease, we might fairly expect them to enjoy better health. To complete the ventilation of the decks, channels are provided. These are nothing more than the substitution of a strongly constructed air channel, in place of one or more of the planks forming the ceiling on each side of the deck to be ventilated. These planks vary in thickness from three to five inches in a channel of the same depth, and from eight to twelve inches in width, in proportion to the size of the ship, and can be constructed so that the iron plate completing the channel above may also be made to be ventilated, greatly increasing the longitudinal strength of the ship. It places no apparent obstacle in the best possible position for ventilating the decks, as it acts immediately upon the air between the beams, where all the foul, heated, and ripened air collects. The deck channels are ventilated similarly, with openings into the main shaft. Together they form a perfect system of ventilation, with the advantage of as many open air passages as possible, as nearly as possible self-acting, available where ventilation is much needed, and causing no draught, as the action is diffused by communicating cross channels, two sides of each being formed by a portion of the cross beam and the deck, completed by a thin wooden batten perforated with holes. It will be seen that this system promotes natural ventilation through aiding the escape of foul air, and providing outlets in the most convenient places for it. The funnel draught is most powerful at all times, but particularly when steam is up. Hollow iron masts, forming three outlets for discharge, are equally effectual in steam or sailing vessels, as they have a constant powerful updraught. Tube and cowl ventilators in connection with these shafts are available for sailing ships, with the advantages of being used either as uptakes, or, when a fresh dry wind is blowing, the cowl may be faced to the wind, when a stream of pure air will be forced through the ship. By either mode the deck atmosphere will be rendered pure. But, as a rule, very small cabins, and even large cabins, where it is naturally take the place of the foul, admitted through hatchways, ports, and scuttles. Other means of ventilation are also available in connection with this system of shafts, such as a steam jet, fans worked by hand, or a fire draught otherwise applied. With the view of ventilation the practice of stuffing the timber spaces with tow of salt, or other protecting substances against dry rot, is totally unnecessary. The existence of foul air in the hold, damaging cargo, as well as causing disease and discomfort, is impossible. The shafts and channels are of easy construction, and, once established, are always available.

Dr. Edmonds' system has already been introduced, by order of the Lords Commissioners of the Admiralty, on board Her Majesty's ship Royal Sovereign, the Zealous iron-cased frigate, and the Favourite. Although under great disadvantages as regards ventilation, necessarily attendant upon their construction, and not having side ports or scuttles, still they will be undoubtedly the objects of the vigilant care of the officers. With respect to the application of his system of ventilation to emigrant ships, I have received from Dr. Edmonds the following observation:—"Of all classes of ships in which ventilation requires the most careful consideration, emigrant vessels occupy the first place. In them we have large numbers of helpless men, women, and children, mostly for the first time in their lives, crowded together in the narrow decks of a ship; unused to the motion of a vessel they become physically prostrate, and mentally depressed; but for the excellent rules of Her Majesty's Emigration Service, carried out under the direction of experienced medical officers, the evil results of improper ventilation would be even more serious. Under present advantages it has been found impossible to effect perfect ventilation of those crowded decks. Effluvia from the hold still further contaminates the air already vitiated to a great extent,
particularly in calms and in bad weather, when it is necessary to close the hatches more or less. It is at these times that the foul air from the holds and bilges becomes most apparent and injurious, collecting chiefly in the higher parts of the ship, in the unventilated spaces. It is one of the worst conditions that the carbonic acid evolved by the lungs or generated by vegetable decay escapes.

Most of the endeavours to ventilate ships have been directed to supply fresh air chiefly by windlasses, but they are too uncertain; and in calms, when most needed, are valueless. Those only who have sailed in an Apparatus, rapidly and successfully, to prevent the stench, have a full idea of the prevalence of this malady during the winter months. During storms, the air is so polluted, and the stench so offensive, that a vessel’s company is often driven to the necessity of cutting off the ventilators, for fear of the health and comfort of the crew be injured.

The introduction of air in the ordinary way cannot be accomplished without creating an amount of damp and discomfort, especially to those berthed in the vicinity of the ventilators, and they must be more common than the air escapes through the cowl-ventilators, cool and pure air occupies its place in the hold and between decks, so long as there is any wind. During calms it is necessary to have arrangements for the supply of fresh air from the ventilator, throughout the ship; a steam jet here becomes a valuable and powerful auxiliary, always available when the natural system fails us.

The steam jet is directed into the hold and escapes through the cowl ventilator, which when steam is used must be exposed to the air; it should be placed near the center of the ship, and for a vessel of 1000 tons should be two feet in diameter. Through this every 100 cubic feet per second the air is conveyed; at a velocity of 10,000 cubic feet per minute of foul air—with a breeze blowing, the velocity will be about ten feet per second; this is sufficient to remove through the hold and deck, and the hatches ventilating the hold, and bilges, and even the passenger deck, the hatches communicating with the hold being then closed. The respiration of a man during one hour is estimated at about ten cubic feet, this quantity of air is thus carried off; and an equal quantity of fresh external air introduced is at the rate of 400 cubic feet per hour for each of 250 individuals. The source of the steam jet is vessels propelled by sails is the condenser. The difficulty of storing sufficient water in a ship for a long voyage has led to the use of distilling water, which is then converted into the purest and most wholesome water; therefore a distilling apparatus is provided in Government emigrant ships, from which a supply of steam can always be obtained, or with the use of condensers, which is generally more convenient, the apparatus is placed in the condenser, and the water distilled. A very good apparatus for this purpose is the one used in the Royal Sovereign, in which a large jet creates a draught of equal strength, and the water distils in the air through it at a velocity of twenty feet per second. But, though this is the manner in which it has been hitherto used, one fourth the quantity of steam divided into a number of minute jets will create a draught of equal strength, with the additional advantage that the escape of steam is almost silent, whereas a large jet creates considerable draught. It will be seen that this very useful and efficient apparatus is available as a perfect means of communication with the mess deck. In steamers, the necessary updraught is created by connecting the smoke with the funnel, up which there is always a draught of from four to eight feet per second, and when steam is up from twenty to twenty-five. Hollow iron masts, which are now coming into general use, are valuable ventilators in connection with this system; they have a constant updraught of from four to ten feet per second. Doctor Edmunds has recently received a report of the practical working of the system, directed to the Royal Sovereign, in which the apparatus is principally of the ship’s framework, otherwise totally unprovided for; it answers this purpose perfectly, removing all foul smells from the bilges, and keeping the air of the deck as clean as possible; its utility is proved by the state of the deck throughout the voyage, and the comfort of the passengers in general.

The steam jet is an important part of the apparatus for fresh air, which I have described. It is an apparatus that has been in use on board the Royal Sovereign, in which the hatches and ventilators have formed part of the Sanitary measures introduced on board Her Majesty’s ships. The Admiralty have directed Dr. Edmunds to prepare plans for most of the ships now being built. In the commencement of the year 1864, Her Majesty’s Emigration Commissioners, ever anxious to have their ships perfect as possible, permitted Dr. Edmunds to carry out his ideas in three of the ships taken up by them—the Art Union, the Earl Russell, and the General Caufield.

The report upon the working of the system specially required by the Commissioners has established its success. The Surgeon Superintendent of the Royal Sovereign, in his report to the Commissioners, states that it was the perfect system of ventilation in theory and practice which he had observed. Dr. Carroll, of the Art Union, in the course of a grand discussion as it affects, states that in the hot latitudes he found the temperature between decks lower than he had ever before experienced; very little unpleasant smell was perceptible in the between decks, nor was the foul air that is usually observed arising at night and from the deck ventilators was in this instance absent. In the calms about the Equator the steam jet was much used; the temperature during its use was reduced, and a very perceptible draught created, which I have examined in the course of my experience in superintending emigrant and passenger ships; and I can only conclude that in Dr. Edmunds’ manner we have every requirement to ensure the effective ventilation of vessels of war and passenger ships. In directing its adoption generally in the ships taken up for the conveyance of emigrants, Her Majesty’s Emigration Commissioners have not only conferred a great boon on these poor people by making their temporary abode upon the waters more healthful and agreeable, but the ships will also, in consequence of their timbers being kept dry and ventilated, resist the dry rot, and last longer, although this is in the eyes of the philanthropist is a very secondary consideration to the preservation of life and health at sea. By conducting the steam jet into the ventilator we increase the current, and thereby discharge the foul air more rapidly—the conclusion arrived at being, that if we succeed in discharging the foul air, the vacant space will be occupied by pure. In the case of steam-ship route of the Royal Sovereign, if we could, we would connect it with the fireplace. As to the adaptability of the system for ventilating houses, I think a very simple arrangement would prove effective, by sifting some of the bbards in each room, and converting the space between the joists into a box three sides air- tight, and the fourth open up air, the air passing through the ceiling of the room below, the air box to communicate through the medium of a tube with the line, the updraught in which would be precisely similar to the forced draught in steamers. By this simple arrangement the losses of rooms, at all times, would be rendered perfectly more perfect, and the heated air of a room, ascending to the ceiling, more effec-
truly carried off. To a certain extent also I should imagine this arrangement would be a remedy for smoky chimneys. To insure a supply of pure air genera1ly obtainable in close streets inhabited by a large population of the working classes, I would suggest an opening in the ceiling of the top landing, terminating in a cow ventilator on the roof; arranged to turn with, and towards the direction of the wind. This would insure the purest air obtainable being supplied to the staircase, hall, and passages upwards and downwards. I am not aware that the current of air through a perforated plate would admit this purer atmosphere. I should be glad to have the opinion of practical men as to the expense of this ventilating arrangement. I cannot think it would amount to more than a few pounds; and surely the owners of property let in tenements would not hesitate, if this may be deemed an important sanitary measure, for themselves and their families, to increase the health, promote the happiness, and prolong the lives of a large and important section of the community.

ON THE SAFETY AND SEAWORTHINESS OF VESSELS.*

By J ohn Ferguson.

Recent events have excited an unusual amount of interest about, and inquiry into, the safety and seaworthiness of vessels, and it may be well for an Institution such as this to give an expression of their opinion, as to whether any course might be adopted which would insure greater safety to our mercantile navy, either in their build, equipment, or management. In fact that every year there are losses amongst the vessels belonging to or trading to and from this country. I am not aware that the losses are increasing in a greater ratio than the increase of shipping; still, from the greater supervision which vessels are subject to, and the improvements which are taking place in their construction and outfit, together with the introduction of steamers into nearly all our maritime commerce, we should expect that the casualties would be decreasing. However, we must bear in mind, that with the introduction of steamers into so many trades there necessarily follows a system of starting on their voyages at stated times, regardless of the state of the weather; and also that, in order to keep punctually to their days of sailing, they are kept going on at times and in circumstances which may not be favourable, or even safe. To prevent as much as possible casualties to passenger steamers, the Board of Trade have appointed surveyors at the principal ports of the kingdom, who periodically inspect the machinery and build granting certificates to all vessels which are fitted up with their requirements, such vessels being provided with boats, lights, and sundry other fittings specified by the Board of Trade. In addition to these, there are rules laid down defining which side vessels are to take when passing others, and also certificates are required that the compasses of iron vessels have been properly adjusted. In fact, we may say that the safety of life and property from shipwreck, or other accidents, is so far as they consider it consistent to interfere with the arrangements of shipowners. To prevent vessels from being shipwrecked on our coasts, we have hothouses to guide, storm signals to warn, and harbours of refuge to shelter. To prevent shipwreck through damage to bulwarks and machinery, the surveyors examine that all is efficient, as far as can be ascertained. To prevent loss by collision there are sailing regulations, fog horns, steam whistles, &c. To prevent loss by fire there are fire-hose engines, &c. For prevention of loss through errors in the compass the certificate of a competent instrument adjuster for all iron vessels. Then, in the event of accidents, they are not unmindful that boats, life-buoys, rockets, &c., are all efficient. Still, for all the precaution and care taken, shipwrecks occur occasionally, under such appalling circumstances, that we are led to ask, Can nothing further be done? The Founders of the London and Amalia, and the immense loss of life and property on our coasts during this winter, together with the inquiries instituted by the Board of Trade into the causes of the loss, especially regarding the two above-named vessels, has brought out many suggestions and opinions as to how accidents to vessels in circumstances may be prevented or mitigated, besides indicating what were the immediate causes of the destruction of these vessels. All our members must have read with painful interest the particulars given in the newspapers of the investigations as to the loss of these vessels—vessels which

we have every reason to believe were strong and faithfully built and well equipped, able to stand the severe buffeting they were when left without steering, and yet they had to succumb to what we might call trifling defects in their deck arrangements. From such events we have much to learn; and if we have arrived at the true causes of these catastrophes, it is a duty which devolves on us to discuss the subject, to see whether any remedy may be found which might tend to prevent the recurrence of such accidents. I can only regret that I cannot undertake to report that the foundering of both these vessels was preceded and accelerated by the immense body of water which was shipped on deck. In the case of the London, the lower part of the ports for taking water off the deck was about 16 inches above the top of the deck, in consequence of there being a box waterway or spirketing, which was as extensive as the deck area. When the decks were filled with water up to the top of that spirketing, it had no way of getting off except by the scuppers, and if these were filled up by the coals washing about the deck, then we can understand what difficulties the crew had in their endeavours to close up the engine hatches, deck pumps, and sounding rods tubes to a considerable distance above the deck; and some people are of opinion that the great length of steamers in proportion to their breadth causes them to be less seaworthy than if they were broader or shorter. It may be an evil to make vessels of extreme proportions of length and beam; the additional strength required to prevent the vessel is increased by the additional strength required; but I am not aware that vessels built of iron, of the usual proportions and construction, are more liable to foundering than shorter vessels. If we are correct in our inferences, drawn from the reports of the loss of the London and Amalia, viz, that their destruction was accelerated by the masses of water which they took on deck, we would naturally conclude that if vessels were so constructed as to be free from the liability to retain water on deck, then they would be free from the liability to founder under similar circumstances. It is the opinion of many that if our large steamers, which have to carry all the weight of passengers and supplies, and where the weight is concentrated in the upper deck, the evil of having the main decks filled with water would be overcome, as in vessels of that construction the water could have no lodgment on the upper deck, and as prevention is always better than cure, it surely must be safer to keep the body of water off the top of the vessel than to have it remaining on, especially where its presence is attended at times with such disastrous consequences. It may be unnecessary to describe the points of difference between a spar-deck ship and one with an ordinary main deck, further than to state that most of our large steamers which carry passengers, and have no spar-deck, have poop and forecabin, or deck-houses, and nearly all have a forecastle, and deck-houses arranged so that the vessel is nearly all covered in, excepting in the part between the poop and the forecastle, bounded by the bulwarks on the one side and the deck-houses on the other. This open space is where any body of water which breaks on board lodges, and where in being crowded, is more injurious. It seems to me the subject is not so much as a question of foundering, and the increased general under the topgallant forecastle, and the officers in the midship deck-houses. In spar-deck ships the arrange-
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL |

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The spar-deck is generally surrounded with an iron railing and stanchions instead of the high close bulwarks required for the other description of vessel. The fact of the spar-deck being several feet high, which is mostly the case, makes it impossible to get above it except after being and even should it get on the spar-deck, there are no barriers to prevent it getting off at once without the same risk of doing damage by breaking into poop, engine-room, coal-batches, etc, owing to the deck openings being so much above the water, which in all cases should be regular on the main deck. I believe that the principal barrier to the adoption of spar-decks for our large passenger steamers is that building in that style, they rate much more in their tonnage than vessels with the same accommodation which have the poop, forecastle, and deck-houses. In the latter class of vessels, the tonnage of the space occupied by the crew is not included in the tonnage of the vessel, unless it exceed one-twentieth of the gross tonnage, when the excess is included in the tonnage; while in ships with spar-decks the space occupied by the crew is included in the tonnage, although the arrangement on the main deck may be precisely the same in both cases. It would be an anomaly that such should be the case, as it is manifestly unfair.

There may have been some good reason for making the law as it now stands, but it is difficult to understand why it should be continued, if it encourages a system of construction in vessels which has disadvantages, some of which I have endeavoured to enumerate. And as the Board of Trade are about to introduce some modification in the tonnage laws, I propose that the measurement of steamers, it might be worthy our consideration whether we should call their attention to the matter at present.

It will be in the recollection of the members of the Scottish Shipbuilders' Association, that after the reading of a paper by Mr. Lawrie on the new measurement tonnage, a committee was appointed to consider the question. The result of the remission of tonnage of all spaces occupied by the crew in all vessels, to an extent not exceeding one-twentieth of the gross tonnage, as at present allowed for forecastles and houses on the upper deck. This memorial was sent in 1863, and in answer the Board of Trade replied that in the event of any further legislation on the subject of tonnage, the points to which you have directed attention will receive the careful attention of their Lordships. Besides having that reply from the Secretary to the Board of Trade, Mr. Moorsom, the late Surveyor-General for Tonnage, in concluding a letter addressed to Mr. Lawrie on another part of the subject, in answering to the question, the remission of the spaces appropriated to the crew in whatever part of the ship it may be situated, whether above or below the upper deck, says—"I have much pleasure in stating that I cordially concur in the views expressed by your chairman (Mr. George Smith) on this subject, and which were so unanimously acceded to last meeting; and I consider it my duty so to express myself to the Board of Trade on their late reference to me of the papers of the Association on the question."

Thus it seems to me that if the Board of Trade and the late Surveyor-General for Tonnage were at that time favourable to the remission of the tonnage of the crew space, even although it was under the main deck, I think that, when we now bring forward as an additional reason that the remission of that part would encourage the constructing of vessels which I have endeavoured to show would be much more safe and seaworthy than the others before mentioned, at the present time, when they contemplate making alterations in the law, it would be well for us to put it to the Board of Trade on this subject without delay, asking them to take the subject into consideration.

The overloading of vessels is another subject which has lately been brought prominently before the public, and it seems to have been under the consideration of the Board of Trade, as to whether they should exercise any control over the loading of vessels, as reported in Report No. 5. Mr. Gibber, in reply to a question put to him in the House of Commons, said—"In consequence of the reports on the loss of the London and Asia's, the question whether the deep sea line could be permanently marked on all vessels carrying passengers and merchandize, had been considered by the Board of Trade, but the difficulties were found to be insuperable, the Government officials having no means of marking the deep water line applicable to all circumstances, or of deciding how deeply a vessel may with safety be immersed in the water."

There is no doubt but there may be difficulties in the way of determining the depth to which vessels should be loaded; but if it is a fact that the loss of many a vessel may be traced to overloading, worthy of the most careful inquiry to arrive at what would be a fair depth to which vessels might be loaded. The underwriters recommend that ships should have three inches of side from the top of the deck to the deep load line for every foot of depth in hold; but we fear that in many cases such a recommendation has no weight or authority.

The quantity of fuel for long voyages, and which by the consumption of fuel are getting lighter every day, it is not so easy to define the depth at which they should leave port. But surely our steamship owners could give sufficient data as to what has proved to be safe immersions. This, with the information from other sources, might decide on the depth to which vessels could be safely loaded according to the season of the year. It might be a question for our consideration whether the draft should be regulated by the depth of hold amidships, or whether the sheer or height forward and aft should be taken along with the midship depth, or in vessels with a great breadth in proportion to their depth perhaps the beam ought to form an element in the depth of load line. There may be some other elements to be taken into account, and I believe that if we could suggest any reasonable proposal to the Board of Trade it would receive their favourable consideration.

In reference to the large number of wrecks which have taken place in recent years in coasting vessels, we learn that many of the nearly all sailing vessels driven on shore by stress of weather. And we see that steps are being taken for the erection of a lighthouse at a point of our Western Islands where it cannot fail to be of service to vessels driven towards that dangerous coast. I think also the erection of a breakwater in Lochindal, Islay, would have the effect of giving some protection to vessels which come to try for shelter among the islands, when they cannot manage to get through the North Channel. Lochindal seems to be a natural harbour of refuge, although at present it is not safe, owing to the want of some artificial shelter.

There are many cases of shipwreck of a much more serious nature, and which have not been foreseen or provided against, but it is a duty which devolves on all connected with shipping to remedy defects wherever they are known to exist; and I hope the members of this Institution will give the subject their best consideration.

In the discussion which followed the reading of the paper, Mr. George Smith, jun., said that he heartily approved of the suggestion made in the paper, that in the tonnage measurement of vessels which had been washed out of the building through the hawse holes. The discomfort was not so great if the vessel was going on a southern voyage; but if it was going a Northern American one, keeping in cold latitudes all the way, it was exceedingly uncomfortable for the crew. It seemed to a man of common fairness that the space in which the crew was accommodated should not be included in registration. Mr. Moorsom, the late Surveyor-General for Tonnage, was likewise of that opinion, and promised that in any future legislation on the subject the matter would receive attention, so far as he could influence the Government. He believed that it was to the Scottish Shipbuilders' Association that the public were indebted for the Jona, and other vessels of that class. Previously it was usual to load such deep vessels as the Jona with all possible trade in the tonnage; but on the representation of that association the Board of Trade agreed to exclude them, and hence the public have been benefited thereby. He had no doubt that if space were allowed for the crew it would also confer a great benefit on seamen.
THE PERMANENT WAY OF RAILWAYS.*

By Robert Richardson, C.E.

The term, "Permanent Way" is employed to distinguish the iron-edge railways on which we travel, from the old cast-iron tramroads, and from the temporary wrought-iron ways used by contractors in the construction of railway earthworks. For constructing these works the temporary, or contractors' way, is beyond doubt a great advance upon the old Dobbin carts, which are still used for removing earth in the formation of docks and canals.

A contractors' way is made up of light wrought-iron rails spiked down to transverse wooden sleepers. It is strong enough to carry two or three tons of earth in each waggon. The old cast-iron tramroads were principally used for bringing coal from the pit's mouth to the shipping port. A short time before a railway is opened for traffic, ballast is spread over the line, and the contractors' or temporary way is replaced by heavier and larger sleepers. These constitute what is appropriately called the Permanent Way; and to this I intend, as far as possible, to confine my remarks in the paper which I now bring before you.

From the beginning of this century to the present time there have been many experiments and trials of new inventions for permanent rails, but without producing any of great importance; for many inventors, ignorant of what had already failed, have re-invented and tried the very same supposed improvements over and over again, each in his turn being unwilling to admit that his scheme was not new. Some of the first inventions sufficed to produce a good ordinary permanent way; and, with the exceptions noted, it is in general a distinct improvement on the old tramroad, after a lapse of more than thirty years, using very much the same sectional figure of wrought-iron edge-rail as was then adopted.

Besides the transverse sectional forms of cast-iron trams and wrought-iron rails, that have hitherto been suggested, there are very many other slight sectional variations used in repairing roads; for engineers are seldom satisfied with those adopted by their predecessors.

In Mr. Smiles' "Life of George Stephenson," he says that a Mr. Beumont employed wooden rails as early as 1830. According to another account, they were laid in the highways in 1832 but, as might be expected, little encouragement was at that time given to the invention. According to Mr. Nichols Woods, the books of the Coalbrookdale Company furnish reliable evidence that in 1767 five or six tons of rails were cast, and from about this time dates the birth of cast-iron rails. They were probably angle-iron rails, for it is mentioned that an iron tramroad was laid near Sheffield, by Mr John Carr, in 1776, which was destroyed by the colliers. That this was merely a tramroad is confirmed by the fact that, three years after, Mr. William Jessop first used cast-iron edge-rails as a new invention.

In 1816, light wrought-iron square bars, two feet long, were imported from Sweden. They were employed by Mr. G. Stephenson, on the Killingworth Colliery Railway. Rails are now rolled as long as thirty-five feet. Two years afterwards, the same gentleman patented a cast-iron edge-rail, which he soon abandoned, returning to wrought-iron edge-rails. Up to this time, railways for the public traffic of passengers were not used to any extent, and little was done until 1835, when Mr. G. Stephenson adopted Mr. Birkenshaw's patent fish-belly wrought-iron rails for the Stockton and Darlington Railway. This last kind of edge-rail was laid on the Liverpool and Manchester Railway in 1829, for the competitive trials of locomotive engines, which were run by the simple suspension of their wheels on the rails. Before this time locomotives had been armed with cog-wheels, that geared into iron racks laid down upon the road to assist their propulsion. It is worth while observing that this company at one time seriously contemplated carrying only goods, some of the directors thinking that to carry passengers worth their attention, would be mere play. The late Parliamentary sanction for an iron tramroad was granted in the year 1901, for a line from the river Thames at Wandsworth to Orpington. Wrought-iron fish-belly rails were, in after years, proposed by Mr. L. K. Brunel for the Great Western Railway; and a model was exhibited by him to the Committee of the House of Lords, previously to the company receiving their Act of Parliament in 1835.

Before the present great railway system was carried to any extent, Mr. Henry Robinson Palmer, an engineer of surpassing ability, and one of the founders of the Institute of Civil Engineers, invented a railway having only one single rail to travel on. The rail was elevated more or less above the ground, and upon it was placed a wheeled saddle, from which panniers to carry passengers were suspended on either side, as they are from the saddle of a horse. To this carriage a rope was attached, and it was drawn along by a horse or mule, as in the case of Mr. Cheshunt in 1830, and another length was laid shortly afterwards in Woolwich Victualling Yard. Mr. Palmer then proposed a double elevated railway, so as to enable the centre of gravity in the carriages to be brought nearly down to the level of the road. This scheme was shown to be the next change in the form of edge-rails was made by Messrs. Stephenson and Locke, and with their united thoughts they produced a double-headed rail. This rail was simply fastened with a wooden key into a cast-iron chair, which was spiked down to transverse wooden sleepers, or fastened to stone blocks. Mr. J. K. Brunel soon abandoned his first theory of fish-belly rails and narrow gauge, for a hollow single-headed rail and a seven feet gauge, which is the system still used on the Great Western line. This rail is screwed down to a longitudinal timber, and between the two are placed thin slips of hard wood, with their grain running across the sleeper. A somewhat similar solid rail is manufactured by Messrs. Stephenson and Venable, and is now universally used throughout France. It is screwed down to transverse wooden sleepers with galvanized iron-wood screws; and, to prevent the workmen from driving instead of screwing them, a little detector is raised on the head of the screw. About twenty years ago the traffic on railways began rapidly to increase, and the great cost for upholstery and repairing railways was sorely complained of. With a view to economy, Mr. W. H. Barlow invented a rail, in which both rail and sleeper were rolled in one length of metal. This rail takes its own unsaid bearing in the ballast, and has the least number of detached parts of any existing deep in repair. It has been adopted on the Holyhead line, between Gloucester and Stonehouse, for the last twelve years. Though somewhat harsh to run over at high speeds, for lines of light traffic, and where the decay of wood is rapid, such rails form a most economical system in construction and maintenance.

Some speculative minds have thought it necessary to make a permanent way elastic. This is fallacious for many reasons, and would be extremely dangerous to travel on at high speeds. What is required is a way that will absorb the violent concussion or blows of a heavy locomotive engine, and only just sensibly yield to the passing load; but this impression on the rails must not be so great as to count amount of the decay of the timber, the true and real meaning of the word. Again, the other extreme of a very deep and very rigid rail has failed, partly because the top surface of the rail spreads out or crushes under the weight before it becomes fairly worn, and this is caused by the unequal expansion and contraction of the metal at the top and bottom surfaces, as they never can be placed in an equal temperature. The vertical section of a rail, to secure this desideratum of contraction and expansion, should never exceed five inches; for even in England, in summer weather, the temperature of the top surface is often as high as 130 deg. Fahr., in the sun; and there is a sensible ringing noise as that temperature alters by the passage of a cloud in the sky, which is a sign that contraction has gone on throughout the depth of the rail, and that the fibres are not being displaced, as they must be in a very deep rail under the same circumstances.

There have been no striking improvements in railway chairs, nor do they seem to admit of any, except in the proper admixture of metal in their manufacture. They have been cast solid, and rolled in two parts, to dispense with wooden keys, and the keys have been drawn in place by screws, but no advantage has been gained. They must be simply attached to the rail, and any method of arrangement of the trucks of the carriages, or the carriages, so to be kept together. Railway keys have been made of many materials—papier-mache, rolled iron rings, cast-iron, and wood. They have been made in one, two, and three parts, and driven or screwed into the chair both vertically and horizontally. The spikes to fasten the chairs are sometimes hollow, at others solid, twisted or split. They are driven at almost every angle into the sleeper.

* Read at the Inventor's Institute.
I will now refer to the schemes for securing the rail-joints. Until 1847, double-headed rails were simply fastened by a wooden or iron key in a cast-iron dovetail, which was very constantly parting, and under traffic the incessant tipping of the rails and joint sleepers involved a serious expenditure for maintenance. With a view to mitigate this evil, in 1845 and 1846 I suggested and carried out some practical experiments, by removing the joint-chair, and suspending the rails at the joints between two intermediate ones fixed near the top, through which one long wooden key was driven on one side of the rail only. This answered beyond my expectation. It prevented the longitudinal tipping, and greatly reduced the cost of maintenance. Improvements in this arrangement, one of which is now still in application at the London and Birmingham Railway, instead of one long wooden one, with other schemes for this purpose, were secured by me, in conjunction with Mr. W. B. Adams, by letters patent, and called by him fish-jointing. We then bolted the fish-plates to the rails, and, after some four or five years of further experiments, solely through the determination of the Permanent Way Company, and great care must be taken to increase the width of the gauge as the radius of the curve diminishes. To permit of a high speed on curves, the outside rail must be elevated more or less, to suit the maximum speed and radius; in a word, gauge and elevation of outside rail have to be accurate, but not uniform; and when this is carefully done, slight jogs in the line will not be noticed. In straight lines for high speeds, for they give steadiness and even pressure in the one direction or the other, while the straight line causes constant vibration. When a railway cannot be made level throughout to work with economy, the necessary inclines should be short, and constantly falling and rising. On a line with such a slope into a devious one, with nuts, is fast superseding all other plans for new lines.

With the present traffic on railways, the bearing surface of sleepers should never be less than 10 square inches per foot forward on a 4 ft. 8 1/2 in. gauge, this surface increasing as the gauge widens. Sleepers have been made very low, as 1½ in., from iron, wrought-iron, and wood—the last being the material most employed, on account of its cheapness, and because it is thought to dispense with the harsh sensation which is supposed to be caused by iron sleepers, but which is often due to many other circumstances. One of the advantages of timber is its great density, and if the sleepers are placed under the chairs and fastenings, no material could be better adapted for sleepers in cold climates. The durability of wooden sleepers is in some measure increased by the use of preservatives. They have been charred, soaked in salt water, and in solutions of mercury, zinc, lead, iron, oil, tallow, resin, cresote, and sulphate of copper. This last is very advantageous, and through the kindness of the Permanent Way Company I am permitted to offer the members of the Inventors' Institute copies of Dr. Boucher's pamphlet, descriptive of his process for preserving timber sleepers from decay, by forcing a solution of sulphate of copper through the wood, in the experiment, has not extended over twenty years. In hot climates, besides decay accelerated by the high temperature, the ravages of the white ants and other insects render even preserved timber worm-eaten, and the preservatives make them brittle; consequently other materials must, for economy, be used. Of these cast-iron is, doubtless, the best. It possesses many advantages; it has a thick, hard crust, to resist oxidation; its dead weight is considerable; it is easily re-cast when broken; it may be constructed so as to present a great bearing surface, and to be free from what is called swerving and rocking; and, by proper arrangements, rails laid on cast-iron sleepers may be made quite as easy to travel on as those placed on timber or iron rail-chairs on timber sleepers. Many miles of cast-iron sleepers, the invention of Mr. P. W. Barlow, have for the last sixteen years been under traffic on the South Eastern Railway in the neighbourhood of Hastings, and for fifteen years on the Etonkilen line. On the Great Eastern line, Mr. James Samuel laid down some timber-rail, 2-bedded cast-iron sleepers, which were under heavy traffic for ten years. These sleepers, with their timber linings, possess the merit of having great strength and dead weight. Mr. Hugh Greaves's system of sleepers, made like inverted bowls, has been for many years used in Egypt, India, and Brazil. Mr. De Bergue's circular plates are used in Spain, and Messrs. Liveysey, Griffin, and other gentlemen, are engaged in laying down cast-iron sleepers, arranged according to systems invented by them. A few years ago the Permanent Way Company prosecuted a series of experiments for ascertaining the breaking strain of cast-iron sleepers, the result of which was communicated to the Institution of Civil Engineers; and I am still engaged in preparing experiments on a new form for cast-iron sleepers. Mr. Wilson is at present laying corrugated wrought-iron sleepers on the Indian Branch Railway, though as yet there has been little experience as to their durability.

The proper laying out of railway curves forms a very important feature in their construction, and great care must be taken to increase the width of the gauge as the radius of the curve diminishes. To permit of a high speed on curves, the outside rail must be elevated more or less, to suit the maximum speed and radius; in a word, gauge and elevation of outside rail have to be accurate, but not uniform; and when this is carefully done, slight jogs in the line will not be noticed. In straight lines for high speeds, for they give steadiness and even pressure in the one direction or the other, while the straight line causes constant vibration. When a railway cannot be made level throughout to work with economy, the necessary inclines should be short, and constantly falling and rising. On a line with such a slope into a devious one, with nuts, is fast superseding all other plans for new lines.

In turn-tables, very few improvements of any importance have been made since they were first introduced. Where there is not sufficient space, to work with economy, which may be seen at most large stations— is very useful and ingenious, as a substitute for them. Before the invention of switches, by which an engine is enabled to run out of the main line on to a siding, two main line rails were made to turn out, so that their ends came in line with the first two rails of the siding. This arrangement was the cause of many accidents, to avoid which Mr. Curtis invented his double-shifting turn-out rails; but still accidents from running off continued, until Sir Charles Fox invented and patented a safety switch, by the use of which it became impossible for an engine to run off the rails. Sir Charles notched the main rail to receive the point of the switch, and Mr. H. C. Wild, by housing the point under the top flange of the main rail, dispensed with this notch, and thereby strengthened the main rail. The point of a switch may be made very stiff, and, at the same time, effectively prevented from jumping up, by housing the end under both the top and bottom flanges of the main rail.

Among the worst faults in laying out a line are incorrect elevation of the outer rails in curves, irregularities in the tilt and gauge, want of sufficient ballast and of room for expansion in the rails, deficient bearing surface in the sleepers, imperfect drainage, and bad iron. These are some of the defects in curves in fixed portions of the track, the destruction of which is accelerated by bent carriage-axles, oval worn wheels, and inequality in the springs of the engine and of the carriages, which produces a jumping motion. Straight lines form the source of another kind of evil. When passing rapidly over them there is a zigzag motion given to the engine and carriages, by which not only the rolling stock, but also the line, is soon thrown out of repair. There is no doubt that the wider the gauge, the greater the
the motive power; but it does not necessarily follow that the safety is increased by a wide gauge. This is fully born out by the practice on the Fostening 5-foot gauge railway, which has proved to be as safe as a 7-foot gauge. Almost every gauge has been employed—2 ft., 3 ft., 3 ft. 4 in., 3 ft. 6 in., 3 ft. 7½ in., 4 ft., 4 ft. 6 in., 4 ft. 11½ in., 5 ft., 5 ft. 3 in., 5 ft. 6 in., 6 ft. 6 in., 7 ft., 8 ft., 8 ft. 2 in., and 7 ft. Often, where the traffic is not sufficient for a broad gauge, it becomes remunerative on a very narrow one; the gauge may represent certain lines of economy, and as far as possible be determined according to those requirements. It may be taken as an axiom never to be lost sight of, that freedom from noise implies perfection in travelling, as it does in arresting destruction; for whenever there is noise there must be friction and heat, which are the prime causes of all destruction of materials.

In conclusion, I may observe that travellers are by no means aware of the almost daily improvements that are gradually going on throughout the entire rolling stock and permanent way of railways. They would more fully appreciate these improvements if they could run out of a first-class line, at a high speed, on to one of the old original lines, such as the Liverpool and Manchester, with its rattles and jolting. Now, indeed, it is far more safe for one to be continually travelling, than to pass an active life under almost any other conditions. This statement is borne out from the official returns of the persons whose deaths were due to causes beyond their own control, on the railways in the United Kingdom. Their number has decreased from 35 in 1844 to 23 in 1859, and to only 15 in 1864, while the numbers that travelled during the last-named year amounted to the enormous figure of 293,350,000, or nearly eight times the whole population of the kingdom. Thus the chance of death is 1 in 15,300,000, which may be taken as practically the same as that of the railways of the United States, as compared with the liability to fatal accident from horse conveyances in London alone, with its population of nearly 3,000,000. By the returns from the Registrar-General's office during the year 1865, there were 216 persons killed by horse conveyance, or 1 in every 14,000 of the population. The same returns also give a result of 1 in every 2,000,000 of population, or 1 in every 15,300,000 of travellers; so that, taking this estimate by population, the railways are 100 times more safe than the streets of London; while, if it be taken by the numbers travelling, they are nearly 1100 times more secure against fatal accidents.

ON THE SECURITY OF IRON SHIPS.

By William Fairbain, C.E., LL.D., F.R.S.

It must appear obvious to every person connected with iron shipbuilding that much has yet to be done before it can be affirmed that the material is as well tried and as well understood as it is in the case of wood. It will be observed that we have the material—of all others the best—to attain desiderata of such immense importance, but it requires careful consideration, and sound judgment in its application, to fulfil all the conditions of which it is capable in construction. In the form and build of merchant vessels intended for long voyages, and adapted for passengers and cargo, it is desirable to have them properly considered in reference to speed, capacity, &c.; but this class of vessels—if we were to judge from the strength, forms, and other conditions of the Royal Charter and the London—do not appear to inherit all the qualifications necessary to render them safe and comfortable at sea. For the attainment of speed great improvements have unquestionably been effected, in giving to the bows fine lines of entrance and an equally fine run to the stern; but the question arises whether this sharp, cut-water shape is not destructive of other good qualities necessary to be observed in sea-going vessels. The introduction of iron as a material of construction has given to the naval architect and builder facilities never before attained for the introduction of the forms best calculated to meet the requirements of high speed. Vessels of that class are, however, better adapted for the navigation of rivers and lakes than the open sea.

In this communication it may not be without interest if I endeavour to show the advantages and disadvantages of the leading features of these high-speed constructions, and to exhibit the difference which should exist between a vessel intended for the navigation of smooth water, and another that has to contend with the rolling seas of the Atlantic.

For the first class of vessels it is necessary to have great lengths, narrow beams, and diminished depths; for the second, it is important that these dimensions should be altered in order to meet all the contingencies of strain in a rough sea. For example, if we take a vessel 330 feet long, 40 feet beam, and 26 feet deep, we arrive at the following proportions, of eight times the beam and twelve times the depth, for the length. Now, a vessel of this construction, with fine lines, is admirably adapted for a sea under favourable conditions, and her security may be doubtful, if heavily laden, when subjected to pitching and rolling in a tempestuous sea. A vessel of this description would be wet and most uncomfortable, and her want of buoyancy at the stern and bow would cause her to bury her bows to a considerable depth when pitching, and sweep her decks with tons of water as she rises to the surface. But this is not all, as at every plunge the ship labours heavily, and suffers severe strains by the weight of water she has to lift in ascending from the middle to the crest of the wave. In every case of high speed in smooth water these proporions one and fine lines are highly advantageous; but in those intended for long sea voyages it is construction, whether or not light sacrifices should be made as regards speed, and some modifications effected in the build, in order to meet all the requirements of a safe and convenient vessel.

In this communication it will not be necessary for me to enter upon the question of resistance to some of its points. My object is to show that they are in actual existence; and hence, from their slight build and great length, have comparatively but a small margin of strength, and are therefore not trustworthy in cases of a heavy cargo and foul weather at sea. To render vessels perfectly seaworthy, I would venture to recommend that the lengths should never exceed seven times the breadth of beam and ten times the depth. In these proportions I am assuming that the ship is strong, and substantially built, and that in place of the lines of least resistance being observed at the bows and stern, additional buoyancy should be given, in order to enable the ship to rise freely on the sea; and by increased displacement the discomfort of the seas in stormy weather would, to a great extent, be avoided. I have been led to these considerations, not so much from the lamentable accident which overtook the ship London, as from the conviction that the safety of a vessel does not so much depend upon its speed as it does upon its sea-going properties; and these, accompanied with sound construction, would tend to reduce the number of accidents, which of late years has produced such lamentable results.

From these observations it is not my intention to depreciate the value of speed in any class of vessels, whether employed in the war or mercantile marine. On the contrary, I think it is a desiderium in both that a saving of time by quick manoeuvring should be a matter of importance; but it is necessary to be some risk of overreaching the question of speed too far, and that to the exclusion of other valuable properties entitled to consideration in connection with commerce and the extended security of vessels subjected to all the trials and contingencies of long voyages and stormy seas.

It is now some years since I endeavoured to impress upon the minds of naval architects and builders the necessity of increased strength in the hulls and upper decks of iron ships, in order to balance the two forces of tension and compression. I also pointed out the advantages to be derived from the longitudinal keelsons, cellars principle of construction, water-tight bulkheads, and double bottoms; and when we consider that the strength of a vessel is the maximum resistance of its weakest part, it follows that any increase of material where it is not required is the very reverse of useful, and never fails to prove injurious. In every structure subjected to strain it is desirable that uniformity of structure should be the object; and I am of opinion that a close adherence to sound principles of construction iron shipbuilding would not only mitigate the evils of which we complain, but would ultimately lead to increased efficiency, and an important saving of the lives and property of the country.
ON RADIATION AND ABSORPTION, WITH REFERENCE TO THE COLOUR OF BODIES AND THEIR STATE OF AGGREGATION.

By John Tyndall, LL.D. F.R.S.

The speaker referred to the relation subsisting between the sensible phenomena of nature, and those processes lying beyond the range of the senses on which the phenomena immediately depend, and it was shewn that the imagination in picturing operations which, though great in their aggregate results beyond all conception, are too minute individually to be capable of observation. He referred to the luminiferous ether that fills space as the most striking illustration hitherto known of the production of a line of thought from the domain of the senses into that of the imagination, and affirmed the existence of this wonderful medium to be based upon proofs at least as strong as those which sustain the theory of gravitation.

Dwelling briefly on the relation of this ether to the atoms and molecules which are plunged in it, he illustrated, by reference to the phenomena of sound, the difference between good and bad radiators. A naked tuning-fork vibrating in free air imparted so small an amount of motion to the air that it ceased to be heard as sound at an inconceivable distance; the same tuning-fork brought into union with its resonant case produced a sound which could be heard by thousands at once. The naked fork was a bad radiator, the combined fork and case was a powerful radiator. This combination of the fork and its case, as regards sound, roughly represented the influence of chemical combination as regards radiant heat. By the act of combination the power of the combining atoms as radiators might be augmented ten thousand-fold. As an example of this the vapour of water was selected. It was affirmed that the sound of this vapour from the top of a high mountain, there heated and exposed before the cloudless heaven, would radiate nine or ten thousand times—possibly twenty thousand times—as much heat into stellar space as could be radiated by either of the constituents of the vapour when uncombined.

The speaker also referred to the well-known analogy between the pitch of a sound and the colour of light; and, throwing a large spectrum upon a white screen, mentioned the relation between the various colours to the rapidity of ethereal vibration. The space from the red to the blue embraced an infinite number of rates of vibration, gradually and continuously shortening without any abrupt or irregular transition. It might be traversed by an infinite series of tuning-forks of gradually augmenting pitch, and all sounding at the same time. This spectrum was derived from the carbon points of the electric light; but it was shown that in the case of various other incandescent substances the spectrum was not of this continuous character. The magnificent stream of green light produced by the volition of the silver in the electric lamp was shown upon a screen, and afterwards the light was analysed, and found to produce two bands of brilliant green, differing but slightly from each other in refrangibility. Here the case is typified, not by an infinite number of tuning-forks, but by two only, or perhaps of slightly different pitch. And just as in vibration in the case of the tuning-fork is a fixed rate, so the rate of vibration of the atoms of silver vapour were fixed. And as the colour of the vapour depended on its rate of atomic vibration, the constancy of this rate secured the constancy of colour in the vapour. We cannot make the vapour of silver white hot, however high its temperature may be raised to, or a white light. It can hardly be said to emit any light at all. The flame of hydrogen, for example, is composed of intensely heated aqueous vapour, but it is hardly visible; and it is easy to give the vapour of water a temperature sufficient to raise a solid body in the vapour to a bright red heat, while the vapour itself remains absolutely dark. Now the powers of radiation and absorption go hand in hand, and the body which cannot emit luminous rays is incompetent to absorb them. The sun's luminous rays pass freely through the aqueous vapour of our atmosphere; while it is the impediment offered by this same body to the radiations from the earth or the cold drain of terrestrial heat, and thus renders our planet inhabitable.

This power of electric absorption was illustrated by the action of two tuning-forks which sounded the same note. Both forks being mounted on their resonant stands, one of them was first sounded. The silent fork was then brought in sounding proximity, and held near its resonant stand. The vibrations of the excited fork were then quenched, but the sound did not cease to be heard. In fact the silent fork had taken up the vibrations of its neighbour, and continued to sound after the latter had ceased to vibrate. Again, one fork being permitted to remain on its stand, the other was dismounted, and thrown into strong vibration. Detached from its stand, its sound was too feeble to be heard by the audience; but on bringing it near the mounted fork a mellow sound rose which filled the room. Thus the vibrations of one fork were transmitted throughout the air and imparted to the other. To effect this transference it was necessary that one fork should be excited by the other; and either of them of a bit of wax not larger than a pea was sufficient to destroy the power of the forks to influence each other.

Thus one sounding body absorbs the vibration of another sounding body with which it is in unison; and here we have in acoustics the representative of that great principle which in optics is shewn to be the basis of the whole science, that bodies absorb those rays which they can themselves emit. Thus green vapour of silver, if interposed in the path of a beam of white light, will absorb the green which it can itself emit. Thus also the incandescent vapour of sodium, itself intensely yellow, cuts clearly out the yellow beam of the spectroscope. And the same is true of aqueous vapour. Its periods of vibration synchronise with those of the rays, or more accurately waves, emitted by the warmed earth, and hence its power to intercept those waves by taking up their motion. But it is in dissonance with the luminous waves emitted by the sun, and hence those waves pass through large quantities of it with unabated radiant absorption.

This incompetence of aqueous vapours to absorb luminous rays is shared by all really transparent bodies; in fact, they are transparent in virtue of their incapacity to absorb luminous rays. Now transparent bodies in a state of powder are always white, and in white bodies luminous rays have no power. The light of the sun, for example, cannot make the table-salt, nor flour, nor a white dress; it cannot even melt snow. The most powerful luminous beam may be concentrated upon a surface covered with hoar-frost without melting a single spicula of the frost crystals. How, then, it may be asked, does sunshine clear away the snow from the snow-capped heads? Two or three days' sunshine on the mountains suffices to obliterate the traces of a heavy snow-fall; how can this occur if sunshine has no power to melt the snow crystals? It is not the luminous rays of the sun which perform this work, but a body of rays which, though possessing high calorific power, have no light in them. By a process of transmutation these dark rays may be converted into luminous ones, but as they come from the sun, and fall upon the mountain summits, they are utterly incompetent to excite vision. Every stream which channels the glaciers or tumbles down the valleys of the Alps is the direct product of this invisible radiation. To do it the glaciers owe their being as well as their dissolution. And the dark rays of the sun falling on the tropical ocean penetrate the water to great depths without considerable absorption, the dark rays are in great part absorbed close to the surface of the ocean, they therefore heat the water at the surface, and are thus since the sole excitants of evaporation. Not only, then, do those in the sols, but, by the earth, give birth to the rivulets of Switzerland, but it is they that lift the material of those rivulets from the sea, and store it on the frozen summits of the mountains.

Gathering up the rays emitted by a powerful electric light and concentrating them upon a small focus, water, alcohol, or ether placed at the focus were instantly evaporated. Air was instantly burned. Air is thus not boiled by the luminous rays, though these produce an impression too dazzling to be upon the eye. Interposing in the path of the concentrated
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

May 1, 1860.

133.

a glass cell containing pure distilled water, the light of the beam is not sensibly diminished, but it is no longer competent to boil or even heat water at the focus. Placing a piece of ice at the luminous focus it is not melted, though, if blackened wood be placed there, it is set on fire. The moment, however, the cell of water is withdrawn the ice melts—melts because the dark rays previously absorbed by the water of the cell are now absorbed by the glass; the absence of the dark rays, or the darkness, points the sulphide of carbon, for instance—which, when placed at the focus where the whole radiation, dark and bright, of the electric lamp is converged, cannot be caused to boil, can hardly be warmed. Water, for instance, requires a temperature of 212 deg. Fahr. to boil it, then requires only 119 deg. 4 min.; still the former is boiled in a time insufficient to warm the latter.

This arises from the fact, that while water powerfully absorbs the dark calorific rays and allows the luminous ones free transmission, the bisulphide of carbon is transparent to both classes of rays, and hence is warmed by neither of them. Thus also, when it was stated that sugar could not be warmed by the light of the sun, the invisible solar rays were meant to be excluded, for when the total radiation of the sun is converged upon white sugar it is immediately burnt up, the agent of its combustion however being the dark radiation.

It is possible to filter the composite radiation from the sun or from the lamp so as to detach almost completely the visible from the invisible rays. It has been already stated that bisulphide of carbon is transparent to both classes of rays; now iodine, a substance which dissolves freely in the bisulphide, is eminently transparent to the invisible rays alone. Hence, a combination of these two substances furnishes us with a ray-filter, which, when it is allowed to fall on rays, allows the dark ones free transmission. At the dark focus we can boil water or alcohol, but we cannot warm bisulphide or bichloride of carbon. Bromine also, notwithstanding its volatility, bears exposure to the focus without being heated. Sulphur also bears the temperature of the fire for a considerable time without heating. Common phosphorus, a combustible so quick that the warmth of the fingers when in contact with it suffices to provoke combustion, bears for twenty or thirty seconds without ignition the action of radiant heat at a focus where, in the fraction of a second, plated platinum is raised to a white heat. The phosphorus is in a great degree transparent to radiant heat. The red iodide of mercury strewn on paper and exposed at the focus has its colour discharged where the invisible images of the carbon points fall upon it, but, owing to the transparency of the iodide to radiant heat, it requires some exposure to produce the thermograph. This red substance is far less absorbent of radiant heat than white paper, and hence it is sometimes easier to obtain a thermograph of the carbon points by exposing to the radiation from the lamp the back of the paper on which the iodide is strewn, than by exposing the face covered with the iodide. It is often, indeed, more easy to burn a thermograph through the paper than to discharge the red iodide. Hence, white paper may be protected from radiant heat by being covered with a substance like the iodide of mercury.

We are here naturally reminded of the experiments of Franklin, which consisted in placing cloths of various colours upon snow, and observing the depth to which they sank in the snow when exposed to direct sunshine. Franklin concluded that the lighter the colour of the body the less is its power of absorption. The generalisations founded on this experiment are for the most part fallacious. Results long ago obtained, establishing the vast influence of the chemical constitution on radiant heat, led the speaker to contrast iodine, an element, with alum, a body of highly complex character. Both substances were in use, one being dark, the other white. Exposed to the radiation from various sources, the white powder proved itself in all cases the most powerful absorber. The dark powder of amorphous phosphorus was also compared with the hydrated oxide of zinc, but the white powder was the more powerful. Bodies of the same colour compared together showed similar differences. The red oxide of lead for example was contrasted with the red iodide of mercury, and the oxide proved the most powerful absorber. So also the white chloride of silver was compared with the white carbonate of lead, the lead salt proved by far the most powerful absorber. It was regarded as regards the action of radiant heat, white in some cases exceeds black, in black in some cases exceeds white, and the other colours are equally capricious; all evidently depending on the chemical constitution of the substance.

In the case of Franklin's white cloth exposed on snow to sunshine, there is no reason why it should sink at all; there is, on the contrary, reason to conclude that it must rise relatively to the snow surrounding it. For, as regards the luminous rays of the sun, they are alike powerless to warm the cloth or to melt the snow. Whatever effect is produced is therefore due to the dark solar rays. Now, snow absorbs these rays with greater greediness than any other substance; hence the white cloth, which absorbs less than the snow, really defends the snow underneath it from the action of the sun. In order to this protection the cloth, if exposed for a sufficient time, will rise in relation to the surface round, just like a glacier tablet.

But though the cloth is not so good an absorber as the snow, it is nevertheless a very powerful absorber; it comes near the snow in this respect. And when, as in the case of the black cloth, we have added to the absorption of a large portion of the dark rays by the cloth, the absorption of the whole of the luminous rays by the dye, the sum of the absorption of both classes of rays exceeds the absorption by the snow of the dark rays alone. The black cloth will therefore sink in the snow. This is the explanation of Franklin's experiment.

The lecturer concluded by referring to various experiments on the transmission of radiant heat through rock salt; to the influence of salt as a means of intellectual culture; and to the necessary defects of any system of education in which the study of nature is neglected or ignored.

PORTLAND CEMENT.

By M. LEBLANC.

HAVING been charged, since the commencement of the year 1860, with the construction of the floating basin of the port of Boulogne, we have employed in the masonry works of that basin many thousands of Portland cement. We have thus been able to make some observations, which have been checked by experience upon a large and a small scale, upon the qualities which ought to be sought for in this cement, and the best conditions for its employment. Our first researches had reference to the influence of the density of the cement upon its quality.

We took a certain volume, V, of light cement—a cement weighing about 1200 kilogrammes to the metre cube, the weight of it being ascertained by means of a box containing 100 litres, which was filled so as to avoid the pressing of the cement in the most perfect manner possible. We mixed this with two volumes, 2V, of gravel, and then, after carefully stirring them, we made them into bricks of sixteen and a half square sectional area. We then weighed the same weight of the first choice heavy cement—a cement which weighed 1500 kilogrammes to the metre cube—whose volume, v, was rather less than the volume V, and we mixed this with 2V of gravel likewise. We made this mixture into bricks, in the same manner as the first. The resistance to an effort tearing the specimens asunder were—

<table>
<thead>
<tr>
<th></th>
<th>2 days</th>
<th>15 days</th>
<th>1 mth.</th>
<th>1 mth.</th>
<th>2 mths.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortar of light cement</td>
<td>45</td>
<td>90</td>
<td>90</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>V cement 2V gravel</td>
<td>65</td>
<td>70</td>
<td>70</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>51</td>
<td>76</td>
<td>90</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Or in English lb.</td>
<td>112½</td>
<td>167½</td>
<td>193</td>
<td>266</td>
<td></td>
</tr>
<tr>
<td>Mortar of heavy cement</td>
<td>65</td>
<td>130</td>
<td>130</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td>V cement + 2V gravel</td>
<td>85</td>
<td>130</td>
<td>130</td>
<td>210</td>
<td>310</td>
</tr>
<tr>
<td>Average</td>
<td>75</td>
<td>150</td>
<td>150</td>
<td>210</td>
<td>310</td>
</tr>
<tr>
<td>Or in English lb.</td>
<td>173¼</td>
<td>226</td>
<td>266</td>
<td>355</td>
<td>420</td>
</tr>
</tbody>
</table>

Thus proving the incontestable superiority of the heavier cements.

We asked M. Harvé Mangon to analyse these cements, at the School of the Ponts et Chaussées, and he found they were of the following composition:—
not, in fact, retain a trace of this mortar. Portland cement mortar is not rich and soapy, in the style of the lime mortars, properly so called. It does not stick to the trowel, but it is like pounded glass that is moistened, so bad an aspect does it present when it is rather stiff. Treated with sea water, this mortar separates into three parts or strata. The upper stratum A, is one of lime water, the middle B, is the soapy unless it is dried. The middle part B, acting as would a mortar that is of the kind known as "thin," whilst the residue C, appears alone to preserve some qualities of the mortar; but composed as it is of the heaviest grains, which are also the best burnt portions of the cement, it does not set with anything like rapidity. Its formation, diminished in strength by the mixture of a great part of the gravel, which enters into the composition of the mortar, which falls with it into the intervals which are left between the stones. Indeed, the density of the Portland cement is much nearer that of gravel than that of lime. It would appear then that the tendency of the elements of the mortar to separate would be less in the case of Portland cement mortars than it would be in those made of ordinary lime. But there is not the same adhesion in the grain of Portland cement to the materials with which it is mixed. Moreover, the mortars that are met with in commerce do not weigh more than 1300 kilogrammes, which are pressed, and measure in a box containing 100 litres. The best mortars from the abbey of Boulogne, measured in the same way, weigh as follows:—1 deg., when very dry, nearly 1700 kilogrammes; 2 deg., when moist, nearly 1500 kilogrammes. Adopting this last figure, the density of the gravel would only be 25 per cent. greater than that of light Portland cement. But even when the density of the cement and the gravel becomes notably exaggerated; for the effective weights in salt water become 200 and 500 kilogrammes, that is to say, that after the immersion the weight of the gravel would be found to be more than double that of the cement. It is this fact that may account for the ready separation of the elements that enter into the composition of the mortars that take place in water.

M. Hervé Mangon has kindly repeated this experiment of washing, with pure cement. The cement that he operated upon presented the following composition:—

<table>
<thead>
<tr>
<th>Element</th>
<th>Form (g)</th>
<th>Supposed weight (g)</th>
<th>Deprived weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>2.60</td>
<td>2.62</td>
<td></td>
</tr>
<tr>
<td>Alumina and peroxide of iron</td>
<td>3.09</td>
<td>3.80</td>
<td></td>
</tr>
<tr>
<td>Lime</td>
<td>6.15</td>
<td>6.10</td>
<td></td>
</tr>
<tr>
<td>Magnesia</td>
<td>0.30</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Water, carbonic acid, and matters not dozed</td>
<td>3.00</td>
<td>3.00</td>
<td></td>
</tr>
</tbody>
</table>

It weighed 1440 grammes when it had been sifted, and it left, in the course of that operation, the following results:

<table>
<thead>
<tr>
<th>Grain size (millimetre)</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.14</td>
<td>0.70</td>
</tr>
<tr>
<td>0.1</td>
<td>0.70</td>
</tr>
<tr>
<td>0.09 to 0.1 millimetre</td>
<td>0.40</td>
</tr>
<tr>
<td>0.08 to 0.09 millimetre</td>
<td>0.30</td>
</tr>
<tr>
<td>Powder passing through a sieve 36 meshes to the centimetre</td>
<td>0.63</td>
</tr>
<tr>
<td>0.18</td>
<td>0.70</td>
</tr>
</tbody>
</table>

The cement in its natural state, and mixed with the ordinary precautions, sets immediately under water. The parts that were extremely fine also set with equal success. The grains that were kept back by the sieve did not work up well, and they retained the appearance of sand; but with time, and even under water, this product set, and acquired a considerable degree of hardness. Thus the cement fulfilled all the conditions that were required, either as regards the chemical composition, the burning, the density, or the degree of pulverisation. M. Hervé Mangon then dissolved in ten litres of water 800 grammes of this cement; he shook it, and then it poured off the water that had been allowed to clear itself. Lastly, he poured the cement thus washed into a smaller box, where it divided itself into three layers, which presented the following differences, according to the chemical analysis:

<table>
<thead>
<tr>
<th>Element</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>7.15</td>
<td>10.20</td>
<td>22.30</td>
</tr>
<tr>
<td>Alumina and peroxide of iron</td>
<td>5.30</td>
<td>3.00</td>
<td>4.30</td>
</tr>
<tr>
<td>Lime</td>
<td>18.80</td>
<td>25.80</td>
<td>48.00</td>
</tr>
</tbody>
</table>

THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.
The Civil Engineer and Architect's Journal

May 1, 1866.

**THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL**

135

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In the same manner water runs over fresh concrete without any serious consequences, except in the case of great speeds and great falls. To fill, by the means of the basin of the floating dock of Boulogne, that reserved portion, we had formed with complete success, on one half of the width of the passage, the first portion of the bed of concrete, the water being allowed to come on the other part; store-decks were thrown over the half bed of the current—the stream of water that was retained by a rim formed in the earth—and we filled the half that had remained empty, and thus on successively passing the water over two sides.

We have thought that the stability—if we may express it thus—of the Portland cement mortar was in a great measure due to its great weight, which is more than half as much again as that of ordinary lime. In fine, if the concrete made with cement is with difficulty applied in water, it is a possible to apply it dry and hard, charged with springs without inconvenience. If, however, it were absolutely necessary to apply it in water, we would recommend the use of machinery, in the style of "tremies," in preference to any others; for the two facts we have mentioned prove that a layer of Portland cement concrete may be spread under the water with the tremies with less alteration than a similar layer of lime mortar. We also would recommend that the stone that should be washed should be washed with thin water, with angular stones that are the result of the breaking of the ballast, for it is extremely important to facilitate the sliding of the materials one upon another, to make up for the want of an unctuous character in the Portland cement. We may here observe that a round pebble from our shore seemed to us as difficult to detach from a quartz of Portland cement mortar as a stone that was broken could be.

**Mode of using Portland cement mortar in masses of masonry.**

In the execution of masses of masonry we think that it is a good practice to employ the mortar of Portland cement sufficiently soft so that movement may be made in beds that would form the seating of the stones, otherwise there is danger of the formation of many vacua under the masses; for the stiff Portland mortar acts as ordinary earth when it is worked with the trowel. Soft, however, it assumes a distinct character; it becomes more unctuous, and spreads more easily in the beds.

An excess of water, as might have been expected, has produced a weakening of the mortar; but if the stiff mortar yields resistances that are superior to those of fluid, and very fluid mortars, it does not yield results that are comparable to those of the normal mortar, even when this is mixed with a great quantity of water.

The stones used as ashlar and laid in elevation, the mortar of Portland cement which does not stick to the trowel (we may observe, moreover, that the ashlar stones of the floating basin at Boulogne, which are obtained from the carboniferous limestone of the valley of Heroueze, in the neighbourhood of Marquise, are the mortar that is used in the mass of the stones of our moat, in the mass of its moisture, and in hardening, to allow the formation of hollow spaces by the effect of shrinkage under the beds, of which the existence is brought to light in times of rain. Thus by reason of the porosity of the material, the rain water, driven by the wind, can fill up the hollow spaces, which are made apparent to the eye by the formation of the moisture. The greatest care must, therefore, be taken to ensure the strict obtimation of the beds that should be perfectly resisting, and this would imply great skill on the part of the mason charged with the setting.

The following seems to be the best method to be observed in this case.---The workmen commence by spreading upon the beds of masonry a layer of mortar of two or three centimetres thick that is sufficiently stiff; they place about the angles of the face two wedges of a wood that is very tender, and these are driven in throughout their length; they equally wedge up with this mortar the undulation of the layer; they can be easily withdrawn by hand as soon as the bed of mortar has hardened a little.

The shrinkage that the Portland cement is exposed to ought to cause its rejection for the use of pointing mortars that are too

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<table>
<thead>
<tr>
<th>Material</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesia</td>
<td>2 0</td>
<td>1 0</td>
<td>0 30</td>
</tr>
<tr>
<td>Water, carbonic acid, and carbonates</td>
<td>8 6 7</td>
<td>5 9 0</td>
<td>2 5 10</td>
</tr>
<tr>
<td>Chlorides and sulphides</td>
<td>1 0 0 0</td>
<td>1 0 0 0</td>
<td>1 0 0 0</td>
</tr>
</tbody>
</table>

---

The layer A was, in fact, a pure lime water; the lime was in part replaced with magnesia, which being more voluminous than it was, opposed anything like cohesion of the product. The layer B having been thinned by the mixture of a small portion of the cream of lime, was principally distinguished from the layer C by the differences in the physical states of the layers. The layer C alone set in a satisfactory manner. In this case, again, the chemical analysis explained sufficiently the facts that had been expectedly preserved. Moreover, it is said that, in the opinion of M. Herve Mangon, there does not exist in the actual state of the fabrication of cements a product of that nature which would resist such an energetic washing, particularly in sea water.

This being settled, let us examine the conditions of the laying of the beton on the level of the water and under the water.

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**Case the First.**—The ordinary practice—that consists in laying the fresh concrete a little behind the mass already in place, and then compressing it by rammers, so as to cause the wet concrete to swell and advance forward, while it always presents the same surface and is never concealed—should, it should be said, be only used in the cases of mortars which are more stiff, for that. The long slidings, which are occasioned by the widening of the mass that is spread out, and which is flattened in laying, causes the beton made with lime to advance slowly, and it is accompanied with an insensible degree of washing; these slidings did not take place with Portland cement, generally speaking. It is almost impossible to keep up a gentle slope with this description of beton. Now when the slopes are very steep, the stones detach themselves and roll down, and thus the washing is produced. In this matter there may be observed in the whole height of the mass (but particularly about the level of the action of mortars) a more or less marked division of the mass. The best is made with the stones that are cemented, screens imperfectly filled with gravel and the coarser grains of the cement, which constitute a mortar that is very thin, that covers the rest of the cement mixed up with a cream of that material, more or less mingled with the cement. Above the water the concrete is excellent.

Let us now consider the case wherein the concrete is executed under water, by means of boxes of a capacity which, as will be seen hereafter, is advantageous to make as large as possible. The heaps of concrete are disposed one by the side of the other, but which have necessarily their slopes very steep, for the reasons before enumerated. In each heap the heart alone can be very sound, so that if the position should contain any springs, it is tolerably certain that they will appear upon the surface of the layer of concrete when the excavation of the interior shall be laid dry; the springs will, in fact, follow the lines of the washed stones. The action of water may be produced with lime mortars; but we believe we may affirm, without fear of being contradicted by facts, that they are much more serious with the beton made with Portland cement. The layers of mortar made of lime flatten more; we have in their case to deal with a complete layer, not with heaps that are just-posed. But laid dry, the concrete made with Portland cement reassures all its advantages over the concrete made with ordinary lime. Thus we have often noticed that a spring from below has forced a passage through the concrete made with Portland cement, like a hole pierced by a ball; the water had passed through, but the concrete only allowed its passage through the passage that was strictly necessary. All around the hole, from the top to the bottom of the spring, the cement mortar retained its goodness. The concrete was pierced like a chimney whose diameter was reduced to just the dimensions that are absolutely necessary.
rich. The best composition of this description of mortars seems to us to be that which is produced by a mixture of 700 parts of Portland cement to 1000 parts of gravel. To diminish as much as possible the porosity of the joints it is necessary to stipulate for a most energetic method of the compression of them by the tool that is used to draw the joints—in France, by the degree. The mortar is, moreover, much solidified by this operation. Now we have had occasion to observe practically that bricks made with compressed mortar offer a resistance that is much greater than in bricks which are made in ordinary mortar prepared in the ordinary manner.

Amongst the remarkable properties of Portland cement mortars it is important to mention that it is beyond the effects of frost. The Portland cement mortars do not freeze, as our masons say; and this allows the execution of masonry in the cement in the winter season in cases of need. Thus, portions of Portland cement mortar which we had exposed to the frost immediately after they were prepared, had cracked very deeply after they were made, and before they had taken their definite form, in consequence of the freezing of the water, and had even partially fallen to pieces to a great extent, but after the thaw had preserved in the detached morsels the greatest hardness.

We will terminate this note by some words upon the influence of the degree ofacity of the ingredients mixed with the cements, and upon the ultimate resistance of the mortars. We for this purpose made bricks that were composed of the following ingredients, namely:—

Rich mortar

1 of Portland cement and 2 (in bulk) of the gravel of la Creche

Thin mortar

1 of Portland cement and 2 of the Downs sand (all in bulk)

1 of Portland cement and 4 of the gravel of la Creche.

1 of Portland cement and 4 of sand.

The sand that was obtained from the Downs was employed very fine; it did not leave any residue upon a sieve of eighteen meshes to the centimetre. The grains of gravel, on the contrary, were retained in about the proportion of one-third by this dimension of hole. We obtained the following resistance to tearing asunder, that are found in this table:

<table>
<thead>
<tr>
<th>Composition of the</th>
<th>Weight producing rupture by tearing asunder after—</th>
</tr>
</thead>
<tbody>
<tr>
<td>bricks.</td>
<td>6 days.</td>
</tr>
<tr>
<td>1 vol. Portland cement</td>
<td>65</td>
</tr>
<tr>
<td>1 sand</td>
<td>65</td>
</tr>
<tr>
<td>1 cement</td>
<td>65</td>
</tr>
<tr>
<td>2 fine sand</td>
<td>65</td>
</tr>
<tr>
<td>1 Portland</td>
<td>70</td>
</tr>
<tr>
<td>4 gravel</td>
<td>70</td>
</tr>
<tr>
<td>1 Portland</td>
<td>70</td>
</tr>
<tr>
<td>2 fine sand</td>
<td>70</td>
</tr>
</tbody>
</table>

It follows that the relation of the loads carried by the rich and the thin mortars, or those that were mixed with large proportions of sand, is as 1 : 0.136.

This would lead to the prescription, in a general manner, of the use of fine sand in the preparation of thin mortars.

These materials are then, carbonate of lime, nearly pure, to which the sea water has added a little magnesia. We find moreover similar matters everywhere that the water can penetrate through the mortar that is made of cement.

ROADS AND RAILWAYS IN INDIA.

By Sir William Denison, K.C.B., Colonel, Royal Engineers.

Looking to the fact that the Government of India, although it has nearly all large and small roads and railways as well as upon canals, when opportunities of constructing these were afforded, has yet many thousand miles of road to make, and fresh lines of communication to open, I cannot but think that an inquiry into the circumstances which influence the cost of transport in India, and a comparison of the advantages presented by different modes of communication, would be useful, not merely to the Government, but to the capitalists who may be disposed to invest money in works of this kind, and who, of course, would wish to derive from such investment the largest return.

Such an inquiry, will I think, tend to prove that the local features of the country, the character of its climate, the peculiarities of the people, and the nature of their industry, system, influence, far more largely than many are apt to think, the discussion of questions which would seem, to most, to be simple matters of engineering experience.

Before, however, I enter upon this inquiry and comparison, I must premise that the facts which I propose to classify and arrange, as the basis of any inferences I may draw, have reference to the Presidency of Madras, which occupies by far the largest portion of the southern extremity of the Peninsula of India. There is, however, a marked similarity between the state of things in the different Presidencies; and, with some trifling allowances for local peculiarities, I think that what I have to say about railroads in Madras will be found applicable to the whole of India.

General aspect of the Country.—The Peninsula of India extends from Cape Comorin in latitude 8° N. to latitude 20° or 21° W., at which point its width is about 14° of longitude or 800 miles of meridians.

A range of mountains from 6000 to 6000 feet high runs parallel to the western coast at a distance of about 50 or 60 miles from the sea. This range is broken through at one point, where there is a gap of about 40 miles in width, the height of which is not more than 1200 above the sea. The fall of the ground to the westward is therefore rapid, while, speaking generally, there is a gradual and much more gentle slope to the eastward, which is interrupted occasionally by abrupt secondary ridges rising to a height of 2000 or 3000 feet. Near the east coast the land slopes gradually towards the sea, at the rate of about 4 feet per mile, in great plains, where there is but little to catch the eye, or to relieve the monotony of the landscape. It follows from what has been said above, that the rivers flowing to the west coast have short and rapid courses; though, as they flow through a narrow belt of alluvial soil near the sea, they are often navigable for small craft for some miles from the mouth. Those that flow to the eastward have a much longer course, and, as they drain a much larger area of country, they bring down, during the rainy season, a very heavy body of water; as, however, the supply is but temporary, as will be seen when I speak of the climate, these rivers do not afford any facilities for water communication in their unimproved state.

Climate.—The position of the Peninsula, within the northern tropic, exposes it to the action of the periodical rains. These are modified in their action by the relation of the peninsula to the great mass of the continent from which it projects, and assume the form of two distinct monsoons. The south-western, which is the far more extensive in its action, commences about the middle of May, and, so far as the Peninsula of India is concerned, extends its force principally upon the west coast, and the range of mountains parallel to it, where, during the months of June, July, August, and part of September, there is a steady down-pour with an occasional break; the average rainfall may be put at 180 inches.

Of course a large proportion of this water returns rapidly to the sea on the west coast; the effect being to lessen the saltness.
of the sea, to such an extent as to kill the fish and all the plants which are naturalized in salt water, for several miles from the coast, and to cause thereby a most disagreeable putrescent effluvium along the coast, and for three or four miles out to sea. A portion of the population of the coastal belts generally live upon the eastern slopes of the mountain range, and drains into the water-courses which form the heads of the large rivers, such as the Godavari, Kistna, and Cauvery, which discharge themselves into the Bay of Bengal; causing heavy floods into the lower portions of these rivers. In October the wind veers to the north-west, and the low country is charred and Scorched. It brings with it the rain which it has sucked up in the Bay of Bengal, and discharges it upon the eastern slopes of the Peninsula. The amount however of this discharge, which continues at irregular intervals through November and December, is not nearly so great as that of the south-west monsoon. The average of twenty years gives thirty-one inches as the amount of rain at Madras during the north-east monsoon, and further inland the average is much less, not exceeding thirteen inches.

Rain may be said to fall from May to December in some part or other of the Peninsula; but the 42 or 5 months from January towards the end of May may be termed emphatically the dry season. Nor vegetation takes place, except in situations where water can be found to irrigate the soil; the sky is cloudless, there is nothing to impede the action of the sun upon the ground, which is baked to the hardness of a brick where the aluminous element prevails, and is reduced to a dust where its consistency is less compact.

Cultivation.—From the foregoing description of the climate, it may be inferred that the productiveness of the country depends altogether upon the periodical rains. Should nature pause in her action for a single season, the result of this short cessation would be such a wide-spread famine as would destroy millions upon millions of the population. And during the dry season, the drainage of the country. In every water-course or line of drainage, dams will be seen following each other in regular succession, till all or nearly all of the drainage water is caught, and retained for agricultural purposes; the surplus, which finds its way into the rivers, is again stopped by dams, and so is repeated as far as possible to increase the proportion of cultivated land. When all this has been done, there is but a small proportion of the cultivated land which is susceptible of irrigation, the remainder being dependent upon the rainfall, and the amount of rains, and so far as the climate permits to dry crops; namely, various kinds of millet and ragi, and also with oil seeds, gram, and other leguminous plants. This dry cultivation imposes upon the farmer the obligation of completing his agricultural operations rapidly: he cannot plough before the first rains have softened the ground; he cannot sow till he is pretty certain of cessation showers of rain. The result is that he is compelled to maintain, or at all events to employ, a pair of bullocks for every five, or at least for every eight acres of land which he cultivates, as he would not be able with less animal power to carry through the various ploughings and hoeings which the land demands. The crop springs up rapidly, and is just coming to maturity when the sun nearly sets, and is ready for reaping in four or five months. It is then reaped, trodden out by bullocks, as was done in the time of Moses, and winnowed by the wind in a manner as old-fashioned as the threshing. When all this has been done, the farmer, unless he has land which he can irrigate, and from which he can get grain within the periods of the dry season, during the five or six months of the dry season; they are, consequently, employed in conveying produce to market, and the farmer or cultivator, leaving his land to take care of itself (which it does by producing a plentiful crop of coarse grass and weeds) attaches his bullocks to a light cart or bundy, and becomes a common carrier. The route being one of easy profit, as every penny which he receives, in addition to the amount required to maintain his bullocks, is clear gain.

Population.—The population of the Madras Presidency may be put at 24,900,000, of which about 16,800,000 are employed in agriculture. About 450,000 are congregated in Madras and its suburbs. There are, however, few large towns, though in each district there are three or four towns about which the population congregates more densely than in the rural districts. As a portion of the population is generally diffused even over the face of the country than is the case in England, where the agricultural portion of the community forms a much smaller portion of the whole than is the case in India.

Wages.—A necessary result of this dissemination of the people, and of their employment in the rude processes of agriculture, is the low rate of wages. The different companies upon railways and irrigation works has, by increasing the demand for labour, raised locally the rate of wages; but even now, in parts of the country a little distant from lines of railway, from 2s. 2d. to 4s. per month, or from 32d. to 36d. per day, may be considered as the ordinary and average wages; while generally speaking, the whole of the agricultural labour is paid for in kind. The hire of a pair of bullocks and a man to drive them, and to plough at the same time, is five annas or 74d. per day.

Roads.—Though men and cattle may be hired at a very low rate, as shown above, yet the cost of transporting commodities must depend very much upon the character of the road over which the traffic is to pass. The main lines of road throughout the presidency are, generally speaking, in a fair state of repair, much money having been spent upon them. The principal obstacles to ready communication are the nullahs and water-courses, of which there are many, and which in the rainy season become torrents altogether impassable; while in the dry season the river beds are filled with a loose drifting sand, across which the ordinary carts or bandies, carrying about half a ton, require, to be assisted by many men. The cross roads are in a pretty good order for the character of the traffic which passes along them; but the right of way is generally given to the dust road, and there do not oppose any great obstacle to the movement of goods or produce. A great proportion of the work of transport is accordingly done in that season; the cost of conveyance being about 21/2 annas, or 3d. per ton per mile.

During the rainy season the cost of conveyance is much enhanced, the country roads are soft and damaged by the rain; the bridges are carried away by floods, culverts blown up, &c. The actual labour and risk of conveyance is therefore much greater. In the second place, the rainy season being the working period of the agriculturists, the whole of the animal power of the ryot is expended upon his cultivation, and he cannot, in any way to be expected, spare any of his men or beasts of burden to assist in carrying the produce. The produce is therefore much less competition; to set against this however, there is less traffic at that time of the year, and I am disposed to consider the figures above given as the cost of conveyance, and which were taken from a return furnished by the Commissary General, of the common price for Government transport, to be a fair average for the whole year.

Railroads.—Of these, the Madras, or South Western line, is completed from coast to coast, a distance of 406 miles. The North Western, which is eventually to communicate with Bombay, is open for a distance of 41 miles from its junction with the Madras line. The Great Southern of India line is finished from Negapatam to Trichinopoly, a distance of about 80 miles, but it has yet to be connected with the Madras line by an extension of about 80 miles, which will meet the South West line at a point about 250 miles from Madras. A branch from the Madras line, about 80 miles in length, leads to the military station of Tanjore. When the whole of these lines are finished there will be a complete chain of railway communication connecting the principal military stations in this Presidency with the great depot at Madras; and this latter will communicate directly with Bombay.

Canals.—Of these there are but few. The irrigation channels in the plains of the Kistna and Godavari, and the Yalleru, the Godavari are used with great advantage for local traffic; and there is a canal, connecting the backwaters of some of the rivers to the north and south of Madras; while the Irrigation Company has on hand a project for completing a line of water communication between Kurnool on the Tonnubbidda, and the sea; the details of which rule however the company is altogether unfitted for this kind of communication, owing to the difficulty of securing, either at or below the summit levels, a sufficient supply of water to furnish the lockage and to meet the very large demand on account of evaporation.
I have given this short sketch of the Madras Presidency, and of the existing means of communication, in order to facilitate the comparison which it will be necessary to make between the result of the railway system here and elsewhere.

In England and Australia, the indirect benefits arising out of the railway system afford a full compensation to the country at large for the capital sunk in the railway. The holders of the railway shares are losers, of course, to the extent of the difference between the dividend paid and the ordinary interest upon the capital invested; but every man who travels by rail, and every man who has to send his goods by rail, pays a larger percentage of the amount he would have had to pay had his means of communication been limited to turnpike roads.

In India however, so far as the conveyance of goods is concerned, the indirect benefit is by no means so great as that which is enjoyed by English or Australian merchants. Here the cost of moving goods is about 23d. per ton per mile on the road, while on the rail it may be put at 1½d.; that is, the cost per rail is to that per road as 2 to 5, while in New South Wales it is as 1 to 4, and in England 1 to 5.

The benefit to travellers in India is very great; the facilities afforded by the railway have made thousands travel, who in former times never dreamed of moving from their homes. Still, however, the poverty of the people, the very low wages which they receive, taken in connection with the fact that a very large proportion of such wages is paid in kind, would seem to point to the conclusion that years must elapse before any very great extension of passenger traffic will take place, except in the vicinity of large cities. At the present long rate of 5½ per cent on 3½ miles for 3rd-class passengers, the Madras cooly would only be able to travel ½ miles for his daily wages; while an English laborer would earn enough in one day to carry him 30 miles. A reduction in the Madras rates would, I have no doubt, increase the number of passengers; but it is very questionable whether it would increase the net receipts. If, indeed, the cost of working the railway in India bore the same ratio to the cost of working in England, as the rate of wages in India does to that in England, the lowness of the Madras rate would not have much influence on its net receipts. But in India the cost of freight is added to that of the coal or other fuel, the wages of skilled labour, as engine drivers, &c., are higher than in England, and though the ordinary labour employed about the stations, and on the maintenance of way, is cheaper than in England, it is not cheaper in proportion to the difference of wages, for one Englishman will probably do the work of at least three native. The whole it may be thought, hardly leaves a doubt that the amount of traffic required to pay the interest of the capital expended upon the construction of the railway, as well as to defray the costs and charges of maintenance of way and of locomotive power, must be far greater in India than in England and elsewhere.

Not the interest of capital is one of the heaviest charges against the proceeds of railway traffic, and when the traffic is comparatively light, and not likely to increase to any great extent, it may be more to the advantage of the Government, and of the country generally, that a description of road should be constructed which, involving a smaller outlay of capital, but requiring a somewhat more costly description of locomotive power, would, at a charge little if at all in excess of that of the railway, furnish a return sufficient to keep the road in thorough repair and pay the interest of the capital expended upon its construction, and provide an amount of tractive power fully adequate to the wants of the country, and to the aggregate population of the line, be very much in excess of that required by the locomotive line.

I propose, then, in the remainder of this article to investigate carefully the relation between the outlay and the returns upon various kinds of roads in the Presidency of Madras; namely, the railway worked by the locomotive engines; the railway worked by horses and mules, and the magnesium and effervescent system. Towards this comparison must be the determination of the amount of passenger and goods traffic which is to be taken as a standard quantity, and in order to simplify the calculations, and instead, to substitute matter of fact for matter of inference, I propose to take the amount of traffic upon some given line or road as the basis, and to base my calculations upon this standard.

The Madras or South West line of Railway, extending from Madras to Beyapore, a distance of 406 miles, partakes too much of the character of a great trunk line to justify the adoption of the whole or any other portion of it as a standard of comparison, whether as to outlay or as to the amount of traffic; but the North West line, or the portion of it already completed, viz., 41 miles, may be fairly looked upon, at present, in the light of a branch; and an inquiry into the cost of moving the passengers and goods, related to have passed over this line, by some more simple system of conveyance, will afford satisfactory data as to the relative advantages of railways or other roads.

I may observe that the Madras Railway, though it only paid, during the first half of 1863, interest to the amount of 68 per cent, or 13a. 7d. per hundred pounds of capital expended upon the whole line, did, I have no doubt, pay the full interest of 6 per cent upon the cost of the 40 or 50 miles nearest to Madras; but it would be difficult, if not impossible, to attempt to deal with the line in sections, and to attribute to each its fair share of expenditure and receipts. It is only necessary to say that, with an amount of traffic equal to 385,000 passengers, and 900,000 tons of goods in the half-year, the amount of interest was only, as stated above, 60 per cent. for the half-year, so that 1,300,000 passengers and about 200,000 tons of goods would only pay the cost of traction, of maintenance of way, and ½ per cent. upon the outlay of capital.

The following is an abstract of the nature and amount of the traffic on the North West line, for the half-year ending 20th June, 1863; and the numbers given will, when doubled, form the standard amount of traffic upon which the calculation of the cost of conveyance on the different kinds of roads will be based; the actual cost of the working of the railway being taken.

<table>
<thead>
<tr>
<th>Passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st-Class:</td>
</tr>
<tr>
<td>2nd:</td>
</tr>
<tr>
<td>3rd:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>15,711 × 2 = 31,422</td>
</tr>
</tbody>
</table>

The first and second class passengers will be merged into one of, say 3220. The second class of passengers will consist of 125,000, and the goods will be taken as 25,000 tons. I will now proceed to enter upon a detailed examination of the cost of Construction, of Maintenance of way, and of Locomotive power upon the macadamized road, upon the railway for animal power, and upon the railway for locomotive power, with reference to the above amount of traffic.

**CONSTRUCTION.**

1st. Macadamized Road.—The data as to the cost of constructing such a road as this have been furnished by the Public Works Department, and the amount given below may be considered a fair average of the cost of such roads throughout the principal parts of the Presidency.

<table>
<thead>
<tr>
<th></th>
<th>Foot</th>
<th>Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of road</td>
<td>32</td>
<td>24</td>
</tr>
<tr>
<td>Width of macadam</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of earthworks</td>
<td>£ 15</td>
<td>14</td>
</tr>
<tr>
<td>Cost of macadam</td>
<td>155</td>
<td>14</td>
</tr>
<tr>
<td>Bridges and Culverts</td>
<td>302</td>
<td>14</td>
</tr>
<tr>
<td>Sandstone</td>
<td>40</td>
<td>0</td>
</tr>
</tbody>
</table>

The cost of the earthworks and bridges and ballasting at the same sum as given for the macadamized road, viz, £730 per mile; setting the metal- lized horse traction, a rail 22 lb. to the yard, would be amply strong enough; and as 2000 yards, or an addition of 240 yards to the mile, will be sufficient to cover all sidings, that cost is £192. 8s. 0d. and 28 × 2000 = 112,000 lb., or 50 tons per mile, will be the weight of the rails. These can be delivered at Madras at £5 10s. per ton,
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL

May 1, 1867

and an additional 30s. per ton, making a total of £10 per ton, will cover the charge for conveyance, so that £500 will be the cost per mile of the rails delivered upon the road. Timber sleepers have been found to decay rapidly in this climate; I should therefore be inclined to recommend the employment of stone blocks as supports for the rails: in many parts of this presidency, where the ground crops out on the surface, the stone block would be far cheaper in first cost, and far more durable than any other description of sleeper; but, as these may not be attainable generally, I propose to allow for the use of the iron pot sleepers, which have been employed on the railway. For the horse traction line these may be made lighter than for the locomotive line, but I propose to allow for the same weight and price, that is £1 per pair of sleepers with the connecting tie-rod. I shall allow, however, for a bearing of five, instead of four feet: the cost, under these conditions, of sleepers and sleepers will be £100 per mile.

The cost of laying the railway may be put as on the locomotive line, at 4d. per yard run, the cost for 2000 yards would therefore be £271 10s.

In order to make the action of this railroad perfect, it should be provided with a line of telegraph; and the cost of this, judging from the amount expended upon that on the Malabar line of railroad, will be £290 per mile.

The whole cost of this railroad for animal power per mile will then be as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthwork, including Ballast or Metal</td>
<td>£330 10 0</td>
</tr>
<tr>
<td>Bridges, Culverts, &amp;c.</td>
<td>£202 10 0</td>
</tr>
<tr>
<td>Rails</td>
<td>£600 0 0</td>
</tr>
<tr>
<td>Sleepers and Sleepers</td>
<td>£1200 0 0</td>
</tr>
<tr>
<td>Fixing Rails</td>
<td>£37 10 0</td>
</tr>
<tr>
<td>Telegraph</td>
<td>£90 0 0</td>
</tr>
<tr>
<td>Stables and Rest Houses</td>
<td>£50 0 0</td>
</tr>
<tr>
<td>Sidings</td>
<td>£60 0 0</td>
</tr>
<tr>
<td>Superintendence, &amp;c.</td>
<td>£76 0 0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>£2717 0 0</strong></td>
</tr>
</tbody>
</table>

Locomotive Railway.—The cost of this may fairly be put at the same rate, £125,000 per mile: this has been the cost of the South West line, and it will in this case include the cost of the rolling stock required to work the amount of traffic taken as the standard. The comparison therefore between the capital expended per mile upon the different kinds of roads, and the annual charge on account of interest at 6 per cent. will be as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macadamized road</td>
<td>£750 0 0</td>
</tr>
<tr>
<td>Railroad for Animal power</td>
<td>£237 10 0</td>
</tr>
<tr>
<td>Railroad for Steam power</td>
<td>£12,000 0 0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>£2717 0 0</strong></td>
</tr>
</tbody>
</table>

(To be continued.)

ARCHITECTURAL ASSOCIATION.

The forthcoming meeting of this society was held on the 6th inst., Mr. J. E. Tarver in the chair. The following gentlemen were elected members of the Association—Mr. Alfred Waterhouse, 8, New Cavendish-street; Mr. G. D. Mennie, Overton-lodge, Angel-town, Brixton; Mr. R. M. Marnock, 11, St. John's-terrace, Regent's-park; Mr. Frederick Dyer, 18, Bucklersbury; and Mr. G. Allan, 3, Westminster-chambers.

The Secretary, Mr. Papworth, requested the Society to furnish the Voluntary Examination Committee of the Royal Institute of British Architects, with suggestions as to the mode of conducting the examinations. The Hon. Sec., Mr. Mathews, reminded the meeting that a schedule of suggestions was sent up to the Institute during last session, and it had been partially acted on, with considerable advantage. In connection with this subject, Mr. Ridgeway announced that the Voluntary Examination Class was about to re-commence its session, and invited the attendance of members. After some conversation a resolution to the following effect was proposed by Mr. Ridge, seconded by Mr. T. Roger Smith, and carried unanimously: “That this Association considers it highly desirable that a certificate should be given to each gentleman who passes the examination, stating the class in which he has passed; and that the certificate should bear the seal of the Institute and the signatures of the examiners.”

Mr. Florence called attention to a scheme for the formation of a class to study water-colour drawing under an able master.

The matter had been brought before the committee of the Association, who had expressed their approbation by granting the use of the rooms of the Association for the meetings of the class. Twelve gentlemen were requested to give their names to Mr. Florence, and thus form the nucleus of this class. The first report of this class was read to the meeting, which had been read some time ago by Mr. T. Roger Smith, and he called upon Mr. Ridge to open the discussion.

Mr. Ridgeway said he was afraid the committee, when they decided to have a discussion, did a very bold thing. Their reason for so doing was not simply that they could not get another paper to fill up the evening, for it was impossible that some gentleman would have given a paper on this occasion, but it was thought that an Association like this ought to be able to entertain itself for at least one evening when circumstances required it. The subject of the education of architects was one of wide range and vast importance. So much had been said on this subject in the papers which had been read to the Association by Mr. T. Roger Smith, that it was difficult to say anything new on it, but on the other hand, those papers had not been fully discussed at the time of reading, so that they might furnish matter for consideration this evening. For carrying out its discussion it was necessary that a rule should exist; but as a rule, members of the Association did not display very much difference of opinion; they had no gold medal to give away, and consequently did not even wage the Battle of the Styles. It would be found, however, that they looked upon the subject from different points of view, and this would doubtless form the basis for a discussion. The characteristic class would tell them with great nicety, the exact position which figure drawing should occupy in the architect's education. Mr. Florence would explain how water-colour drawing becomes a necessity of art-education; while our Treasurer (with an eye to the half-quarrel) would insist that belonging to the Architectural Association, and being a member of that Association young men were articulated now, as then, but beyond that nothing very definite was done as to their education; nevertheless, opportunities were now set before the young architects, which the older members of the profession were constantly telling them “to make the most of in their time,” but using these opportunities is purely voluntary, and forms no part of the system. The consequence of the greater development of the profession, was the larger number of men now rushing into it, in which some way had caused a deterioration from the old system of education. For instance, much less time is now spent in study abroad than was formerly the case: this arose partly, no doubt, because medieval architecture could be studied at home; but still, it was a matter worthy of the attention of those who were considering the course of study which ought to be pursued by young architects. Mr. Ridge believed that many would feel conscious that much of the time of pupilage was often wasted in finding out what a student could learn, and the dearer the tuition the more he hoped, assist some of the younger members of the Association in this particular. Mr. Smith's paper, they would remember, ended with a paraphrase of Demosthenes' well known saying as to the most important requisites in oratory. Mr. Smith had said that drawing was the first, the second, and the third essential for a architect. He (Mr. Smith) said at the time of “finding aim the archer never meant,” take the liberty of giving a separate meaning to each repetition of the word drawing. To the first, he would attach the meaning of “Geometrical drawing;” to the second, “Free-hand drawing;” and the third he would call “Drawing from the round.” Making geometrical drawings of exact buildings was the opinion of “Geometrical drawing,” with “Drawing from the round.” In geometrical drawing they had sufficient practice, they were of no use in an office if incapable of doing this species of drawing. On the question of free-hand drawing, Mr. Smith
had hinted that the pupil ought to have some proficiency in it before he entered the profession. He (Mr. Ridge) quite agreed with this opinion. Writing a specification might be considered as a fourth essential. It would be impossible for anyone who entered the profession, ought previously to have passed a year in a builder's office or yard, learning the practical part of architecture. This was not done at the present day, and he thought that this defect lay at the root of the imperfect education of architects. The young men who entered the profession learnt nothing for till first second years at—that work, which lay in a few specifications, of which there were generally one or two dirty, well-thumbed, and grubby copies kept in the office, especially for the pupil's use. He did not undervalue figure drawing, or the proper use of colours; these were very important; but first of all the pupil ought to have a thorough practical knowledge of the details of buildings. There were many books which were, of course, consulted, but it was often enough for the architect, in the absence of the architect's trained eye, to be unable to express it, and the pupil had to be able to make use of it in his own way.

Mr. R. J. Mathews thought that, if a man who had the subject, might be summed up in the words of Mr. Scott, in one of his lectures at the Royal Academy:—"That we should strive to do, not what they did in the middle ages, but as they did.

Mr. Bridge thought that it would be impossible for anyone who entered the profession, ought previously to have passed a year in a builder's office or yard, learning the practical part of architecture. This was not done at the present day, and he thought that this defect lay at the root of the imperfect education of architects. The young men who entered the profession learnt nothing for till first second years at—that work, which lay in a few specifications, of which there were generally one or two dirty, well-thumbed, and grubby copies kept in the office, especially for the pupil's use. He did not undervalue figure drawing, or the proper use of colours; these were very important; but first of all the pupil ought to have a thorough practical knowledge of the details of buildings. There were many books which were, of course, consulted, but it was often enough for the architect, in the absence of the architect's trained eye, to be unable to express it, and the pupil had to be able to make use of it in his own way.
instead of gaining any benefit by attending such class, the results would be a loss of time and disappointment. On the other hand, he thought that the student who had given some little attention to the rudiments of the various subjects in home study would find that associated study was most profitable. As regards the preliminary classes, he considered that, if the students were at home, their time might be better spent attending to Weal's rudimentary treatises, or works of a similar character, possessed of sufficient attainments to make his association with others advantageous. He begged to read an extract from Mr. T. Roger Smith's paper:

"I believe it quite worth any student's while to join the Association for the first few years, for it will not only enable you to follow out their subjects as they apply to the class, but will also enable you to appreciate the work of others, and to see how their attention to certain points, which you might have overlooked, will be of great advantage to you."

He (Mr. Mathews) thought that one of the advantages in association was, that a man had opportunities afforded him of making friendships and securing associates of his own age. Another and important advantage was, that it kept a man in private work a young man off "offering" his work. Another advantage was that by association they were mutually instructing each other. Each man ought to feel that he had a share in assisting the advance of the particular class to which he belonged. It was very easy to sit in a room with a number of young men, all as important subjects as the subject they were studying, and get a great deal of instruction simply by lectures produce the impression which was necessary? Doubtless attendance at lectures was very desirable but it must not be considered everything. It required to be followed up by private and associated study. He (Mr. Mathews) thought it would be advantageous if members of classes were each to select a certain book on the subject to be studied, make extracts therefrom and read them to their fellow students, by which means they would have a collection of opinions, which while groundling each student in his work, would be advantageous to the other members of the class. He commended this idea to the members of the voluntary examination class. He was, he thought, by this exchange of thought that ideas were formed in their minds, and the necessity of thus exchanging thoughts with others should be kept in view by everyone, from the beginning to the end of his life. One other advantage was, that a man could understand much better what he studied, seeing there were points that would appeal to him, and are exciting, and he needed it, having a clear conception of the subject, were made comparatively easy. Mr. Mathews remarked that great attention ought to be paid to minor points in the course of study. As they got older they would find that the things which now appeared trifling were the very ones which mastered them afterwards. Questions on trifling points of this kind were often asked in controversies, and an embarrassing to have to confess that the little things had not been so closely studied as they required. Advertising to the necessity of association, Mr. Mathews said, every man must have companions. The greater number of the pupils in London architecture's offices came from the country. They were frequently unacquainted with anyone in London. Perhaps their fellow pupils in the office were not of the kind they desired for companions. If such young men joined an association, such as our own, they met men of their own age and calibre with whom to form intimacies. Acquaintanceships were frequently formed under such circumstances which were lasting throughout the lives. Hence it was that a great number of successful architects found a beneficial influence upon the formation of his character for the remainder of his career. Again, a most important quality which association tended to educe was perseverance. In whatever line of life a man might determine to walk, perseverance was a most necessary quality. "But whether this spirit of perseverance is awakened, which urged men on to persevering study. This spirit of perseverance would not be so active if the student were to study alone. He (Mr. Mathews) would not deny that there were some disadvantages incident to associated study. In so large a place as the Metropolis there were oftentimes greater delays required before they could meet the place of meeting, and it might be said that the student could improve the time better at home in private study than by wasting it in taking a long journey. It admitted there was a loss of time, but still he thought that, all things considered, the advantage was on the side of class attendance, especially as there was a possibility that if the student stayed at home he would not study at all. Another point which, to those engaged in class study, required to be guarded against, was a tendency to have no decided opinions of their own, but to be content to follow those of the majority of students. This could only be obviated by independent thought. There were many who never got up his mind, and decide for himself what was true and right, and ought not to allow himself to be swayed from his carefully formed opinions without very good reasons. Mr. Mathews concluded by urging upon students the necessity of perseverance, zeal, and love for their work, as without those it would be entirely obliterated. He thought especially desirable in the attendance at classes, which must be strict, but regular. If they were not zealous, and had not love for their work, they could not hope to succeed, and in expressing this opinion he was sure he should be backed up by many who were older and had far more experience than himself.

A Member referred to what Mr. Ridge had said, regarding the benefit to be obtained from studying modern buildings, and said he thought such a practice would be considered "priggings" nobody, of course, would appropriate the entire design of a building, but architects might accuse students of stealing their details.

Mr. T. R. Smith said it was gratifying to find that the Association had determined to fill up a vacant evening, by discussing "architecture," a subject on which he thought, and generally speaking to himself because his paper had been made a subject of ground-work for the discussion. He did not propose to say much on points that had been dwelt upon by other speakers, but would point out that the range which the discussion had taken showed how very much they had to learn. There were many things with which students of architecture ought to make themselves acquainted, as an absolute necessity, and many things which without being essential would yet be very advantageous to know. There were, in truth, but few kinds of knowledge or attainment which the architect would not find of advantage. If this was the case, he believed they ought to work constantly, beginning early in life, and neglecting no kind of study which would be beneficial to them in their career. He advised that they should never miss any chance which might offer of learning anything which affected their profession. They should bear in mind, moreover, that their time was limited, and if they wished to make their studies successful they ought to classify the objects of study, and pay most attention to those subjects which were of most moment. Mr. North had well pointed out the importance of a thorough practical knowledge of the constructive part of the profession. To those who could do it, nothing was better than passing some time in a workshop or on the scaffold. But the most important part of their studies was to study architecture as a fine art—as a fine art, as a constructive art, and as an intellectual art. They ought to know architecture as a skill—as a trade, as a business; but above all that, they ought to know it as a fine art, a mystery over which, was the highest point to attain. It was impossible to know the art, unless they understood the structure and materials, and the purposes for which they were intended; but they might know all that, and still fall short of practising architecture to the best purpose, fall short of the power necessary to make themselves a great name, and to produce buildings which should be a credit to the country and to themselves. He therefore thought it would be very glad if the students should act before them the duty of studying earnestly those things which bore upon the artistic part of their profession. They should no doubt study buildings both ancient and modern; but if they studied modern buildings, he advised them to study only good ones. There were only a few good, and very many bad, among modern buildings, and others of ancient or modern buildings were studied, students should be encouraged to constitute themselves almost entirely alive to that done upon architecture as a fine art; for this reason, that he urged the importance of early attaining great excellence in this branch of study. He taught the students which could be learned late in life, such perhaps as the power of fluent talking; but the students which should be learned early in life, and which were, perhaps, the first twenty or twenty-five years of a man's life. Few learnt languages after that age, and few had much skill in draughtsmanship who had not attained that skill by the time they had reached that age. It was therefore most important to study early, in order to gain skill with the pencil, and they should make this.
a very prominent aim. Notwithstanding what one gentleman had said to the contrary, he was himself convinced that entering an office with some skill in his hand and drawing was of great advantage. When they got into an office, their time was of course taken up by technical matters, and the opportunity of there learning the higher parts of draughtsmanship was rarely great. Their preliminary knowledge would therefore to a great extent fix the amount which they could afterwards attain. At the architect’s business was not to draw fine buildings, but to build them, and the reason he (Mr. Smith) laid so much stress upon drawing was, that they might be able to draught their own designs and to shape and communicate to others their own ideas. Then they required to be well acquainted with the constructive part of the profession. They ought to know the effect which the features introduced into their designs would have when erected. Unless they understood a great portion of the technical knowledge which the workmen had, they would not be able to get satisfactorily executed. For this reason a structural knowledge of buildings was wanted. But it is said that of two equal things one was greater than the other, and if structural knowledge and artistic knowledge were the two things of equal importance, he would say that artistic knowledge was greater than structural knowledge. It was of great importance, and showed the rest, that they should have machinery which was set in motion to assist them. They would find the machinery of classes of great help. The reason why, with only moderate ability, men who had passed through a good school and college often succeeded remarkably well, was that there was such an admirable system of machinery to assist in developing their powers. The theoretical and the practical part of the study of architecture in the present day were few and imperfect, and he thought this in one respect an advantage. Self-reliance was thus developed in the young architect. There was a disadvantage in a perfect system of machinery for education. It tended to produce a large number of architects of the same pattern (Mr. Smith). The system has been so uniformly the most recent architectural work in Paris. One cause of this was, no doubt, the very complete academic system of architectural education there, one natural result of which was that the architects all designed very much in the same style. He was sure that the buildings designed by architects in the reign of Napoleon Bonaparte, if they were built as they were thought of at that time, would be too similar. The uniformity of the most recent architectural work there, the natural result of which was that the architects all designed very much in the same style. It was, by Mr. Smith, a paper so exhaustive, that he was glad his position did not require him to speak on that occasion; he would only venture on one general remark, namely, that the young architects must not be too great a hurry to make their studies remunerative. There was so much to learn, and so much to be thought of, that one felt quite overwhelmed, until the requirements of business recalled one to a practical state of mind. He considered the discussion had been very good, and hoped that the evening’s debate would lead to the earnest study of professional duties.

At the meeting on the 20th ult., the following notices of alteration in the rules of the Association were given. The alterations to be considered at the special business meeting, on the 4th inst.

Proposed by Mr. T. R. Smith, and seconded by Mr. Lewis, that in the new text “the words “two vice-presidents” be substituted for the words “vice-president and the words “more” be inserted before the words “two successive years.”

Proposed by Mr. Ridge and seconded by Mr. Florence, an amendment on the proposed alteration of rule 5, that that rule should stand thus, “The office of president cannot be held by any member for two successive years, or that of vice-president for more than two successive years.”

LONDON STREETS.*

The difficulties and dangers of our streets, about which so much has, during a century and a half, been said and sung, are again the theme of many voices. If we were not the grave and deliberate people that we are, our constitutional immobility did not inconvenience us, nor did we, like many other cities of the eastern coast of our race, we might trust that the reformation in our thoroughfares, which has so long been demanded by sage and satirist, would set in with a swift and steady tide. We have in Trivia a lively treatment on the Art of Walking in the Streets of London, much of which might be given in sober earnest now. Many of the streets are often too crowded, and the tendency of the mob and the surviving Gay’s satire, and terrific vital still. In spite of all that has been done of late years tending to the improvement of our streets, we are driven to ask whether our works of public utility are keeping pace with our advancement in intelligence, in numbers, and in wealth. One of these powers has indeed become steadily demanding for itself a larger measure of regard. Numbers have an inexorable logic, and now that we are proved to have packed ourselves so closely that there is not alone the certainty of interruption in our business, but a very appreciable risk of making an end of our business and ourselves once for all, it is likely that reform may be thought about in earnest. If we are to believe that a mere increase of business, and of intelligence, must produce a proportional decrease of comfort, convenience, and safety, it may be worth considering whether the attraction of the people towards towns is not a mistake. If the increase of wealth upon a given area renders the people less serviceable for the public purpose of the city in which it is one of the great advantages of wealth, it may seem that a little more repulsion amongst the atoms of population would be wholesome permanently, as we know it to be temporarily agreeable.

We know however that there is no necessary connexion between commercial prosperity and public inconvenience. That to keep the greatest number of Londoai in a state of cleanliness and convenience very much in advance of their present condition, is a matter quite within the reach of its wealth, and the skill of its public officers. Will those who represent the tax-payers have the courage to say that this necessary work shall be done, or must we wait till some wise and strong government shall take the management of their affairs out of the hands of the present? The skills of our present condition are too patent, and have been recognised too often in Parliament and in public, to need formal proof here, but it is not often that we have from competent authority a clear analysis of the processes by which people proceed to do each other out of comfortable existence, and a plain statement of the results and the reasons why they are such.

Mr. W. Haywood the engineer to the Commissioners of City Sewers has in his report to the Commission given such a treatise on the state of the city and its wants in respect of highways. It is one of those reports which during several years have occasionally come from the same hand, and the treatment of various questions pertaining to the health and comfort of the community. We have here the views of the responsible officer of a governing body which has interests of unequally magnitude under its charge, and the value of those views is not diminished when it is seen that they are given without the reserve and circumspection which are erroneously supposed to be peculiarly official.

London City is only the core of the Metropolis, and Mr. Haywood does not sever it entirely from that of which it is but a part, though in many respects the most important part. He regards first of the Metropolis and its great centres of traffic. The City of London proposes to give it the advantage of fresh空气 which set in towards it. Lastly, of the improvements that are needed to meet its necessities. The extracts which follow will show how he deals with these matters.

and selects its residences mainly with the view to the facility with which the City can be reached, that improvements in the thoroughfares are principally needed.

The population of the Metropolis was, in 1801, 958,683; in 1811, 1,138,816; in 1821, 1,375,947; in 1831, 1,564,994; in 1841, 1,714,417; in 1851, 2,269,286; in 1861, 2,628,898.

From these facts it will be seen that the total population in 1861 was three times that of 1801, it having trebled itself in 60 years.

By the same figures it may be calculated that the metropolitan population doubles itself in about forty years, and this has been the rate of increase since the beginning of the present century—those sixty years having been divided into three periods of equal duration, during which wars, famine and pestilence, and all those agencies which might have been expected to retard its growth, and this may therefore be fairly assumed as the rate of increase at the present day.

The question may, however, raise much speculation, leading to views adverse to those herein set forth, for such adverse views have been frequently expressed during the last thirty years (and probably at all times), but experience has hitherto been uniform in its contradiction of them. It is possible, no doubt, that they may at length be true, and that all other views as to the future of the Metropolis may prove to have been false, but the practical method of dealing with a matter of this kind is to use the experience which is clearly before us, rather than depend upon theories which, however plausible, have hitherto proved fallacious.

New in the population in 1865 was computed to be 2,092,913, which in round numbers will be 2,000,000, therefore in forty years it may reach 8,000,000, and the waste of the future, as well as for those of the present community, in respect of highways, that provision must now be made.

Now the population double itself in the next forty years, the same annual increase during that period will be about 75,000; and at the expiration of forty or fifty years miles of open country will be covered, more or less closely, with homes for the additional three millions of inhabitants which will then exist.

But there are other causes which have arisen of late years, tending largely to dispense with these thoroughfares and substitute that which is above the operative classes, the principal agency being the facilities for transit offered by railways. The tendency of this class undoubtedly is to seek cheaper residences and a purer atmosphere, and, consequently, to encourage the use of the open areas around the town, and that, probably, sixty square miles of open country, if not a considerably larger area, will be covered and occupied forty years hence, or by the time the population reaches 6,000,000.

For facility of access to this City, a large portion of that population will settle down as near to it as possible. It has been seen that the districts in the centre are already densely inhabited (and indeed the suburbs within a radius of 2 miles from Blackfriars bridge are now closely populated), that the thinly populated area will annually extend farther and farther from the commercial centre, and the more valuable transit, unless ample provision be made at once, will be more and more difficult to obtain. As economy in time is of the highest importance in a community, this difficulty must be avoided as far as possible, and should be considered for the preparation of the site of the day.

This is a subject requiring the immediate attention of the rulers of the Metropolis.

The metropolitan authorities foresee in past years this vast augmentation of population, they might have provided, at but small comparative cost, larger and more convenient highways to meet the exigencies which have already arisen or must soon arise. As matters stand, it is probable that relief must be sought mainly in the construction of lines of railway to carry the suburban traffic. These railways have been termed, not inaptly, omnibus lines, as they carry that class of traffic which previously to their introduction had been carried mainly by omnibus; and these lines must be at least co-extensive with all the main lines, and those of any railway out of London, and should be laid out upon the more complete and comprehensive system than has hitherto been attempted.

But although railway conveyance must soon be used to a large extent by all classes of the Metropolis, it doth not answer, in a greater degree the means of transit as the distance of the inhabited portion extends farther from the City, it will never obviate the usage of other vehicles. For, as the wealth of the Metropolis increases, indiscrimination to the employment of cabs and carriages of other descriptions, which give a dignity to the vehicle, and even to a luxury, cannot afford, will be still greater than at the present day. Although, therefore, railways must prevent the vast and rapid increase in public vehicles which otherwise would be an absolute necessity, still the vehicular traffic will increase, and it is in the highways and thoroughfares of the Metropolis, and specially in those which lead to or are within the City, or such as may relieve the City from traffic needlessly passing through it.

Indeed, highways and railways should be considered together as one question, for they are now concurrent necessities which may be made to assist each other greatly. It is a subject so pressing, that not a day should be lost in entering upon the consideration: to delay is to ignore the teaching of the last half century, and to diminish the chance of remedying the insufficiences in the thoroughfares, which is greater then in any metropolitan or town in Europe.

It is not, however, needful to enter into the question in its fulness here. It is sought only in these preliminary remarks to draw attention to one inadaptable fact, which, in their future effect upon the Metropolis traffic, have never yet been sufficiently considered; to show that the vast population which is in the advent; the large area of ground it must cover with its habitations; the increasing distance those habitations must be from the centre; the traffic the population will generate, and to show that therefore exists for well-designed lines of highway to meet its requirements.

I now proceed to show how the City in respect of traffic will be affected by this population.

The Great Centres of Traffic.

There may be said to be two centres of traffic in the Metropolis the governmental centre, and the commercial centre; the one being at Westminster, the other within the City.

The governmental centre comprises also what may be termed the pleasure centre. It comprehends the quarters inhabited by the nobility, gentry, and wealthy classes of England, and those attracted to the Metropolis during the London season by parliamentary business or for amusement; and is thus localised by the position of the royal palaces and the Houses of Parliament. It has its own special traffic at all times, but its more important traffic has but a season, and that season is determined by the exigencies of the persons who compose the gentry of the Metropolis. The men of the Metropolis and City wend their way; but much of the daily traffic either does not go to the Bank, or, if so, only because there are at that time no other main lines which public vehicles can take excepting those which approach it, and these therefore still present, with all their encumbrances, the best route to and from the various places of business.

I now proceed to the consideration of the elements which contribute to the traffic of the City, and the conditions under which it moves within the City.

Area, Population, Thoroughfares, and Traffic of the City.

Area.—The area of the City, within the municipal limits, is 631 acres, or nearly one square mile. According to the divisions of the Superintendent Registrar of Births and Deaths, the area is 725 acres; deducting the water, 67, there remains of land 658 acres. This is 27 acres in excess of the true area of the City, and the population returns here used to refer to the larger area; the areas and statistics of the thoroughfares must, however, necessarily refer to the true city area of 631 acres.

Population.—The population of the City was as follows at the previous census:

19th century: 1811, 121,234; 1821, 127,976; 1831, 121,234; 1841, 125,685; 1851, 123,608; 1861, 124,717; in 1851, 125,128; in 1861, 113,387.

It was, therefore, nearly stationary for a period of fifty years, but at the second cyclical period was manifestly decreasing, and was, perhaps, lower than it had been for centuries.

The population of 1861 was lodged in 13,631 houses, which is at the rate of 54 inhabitants to each house.

For the purpose of this population, and of all the traffic which belongs to it, the thoroughfares of the City should be made more than sufficient. It is obvious that it is not for their accommodation that improvements are needed, and yet the smallness of the area of the City, and the smallness of its sleeping population in comparison with the whole Metropolis, are comparatively unimportant, when it is estimated to the City's importance according to the space it fills in the Census Tables, and the number of square yards of ground it covers.

Nur will the sleeping population increase, insomuch as the demand for sleeping accommodation is so great. As the Metropolis is the centre of all markets, and public buildings, will gradually and fortunately sweep away the houses which are now so densely inhabited. In their place will arise vast warehouses and structures full of human life in the day, which will not be more densely inhabited than the houses which are to come may be expected to show a diminution in the City population.

The traffic in the City, is, therefore, not materially caused by, nor is it likely to be augmented by its sleeping population.

The present sleeping population, therefore, neither represents the actual population, nor the percentage of the population which is in the Metropolis, and who are only the persons who are often in the Metropolis, for it is mainly composed of the poorer classes, or of those left in charge of the various premises, and would be a representative of the City in any way, although its diminution will indicate the security the merchants and traders of the City enjoy in being able so to leave their vast property to the protection of the City police.

The public ways may be divided approximately as follows:—7 miles...
of main thoroughfare, 28 miles of collateral thoroughfare, 15 miles of minor streets and courts, alleys, passages, &c. There were in 1560 altogether 48 points of inlet to the City, the total traffic of which was, on certain days, taken, by the police. Of these, 39 were bridges, 35 had carriageways and footways, 3 had footways only, 6 were steamboat piers, 2 were water-side stairs, 1 was a railway station; total, 49. At the present time there are four additional railway stations which are inlets, but, as no official notice of the traffic of which these stations have been since 1860, I must herein refer to the traffic, and the conditions affecting it, as they existed in that year.

The total number of persons entering the City upon a day in May 1860, was, according to the police, 23,903, and in the year 1861, of which number 10,705, or 44¾ per cent., came by the public coach service. Of the total number of persons entering the City in 1860, it was found that, during twenty-four hours, the total number of persons entering the City was 708,621. This means no more means of separating this return, so as to arrive at the number which entered the City between 9 a.m. and 5 p.m., and an exact comparison with the return of 1860 cannot be made. I take, therefore, the return between the hours of 7 a.m. and 7 p.m., in 1860 (twelve hours), when there entered the City 257,936 people.

Notwithstanding the large number of persons entering the City, the metropolitan population was estimated at 2,269,180; therefore, during twelve of the busy hours of a day in that year, there entered the City a number of human beings equal to nearly one-fifth of the whole metropolitan population. And as the total number which entered the City during the four hours which were said to be equal to one-quarter of the whole metropolitan population.

The traffic has increased since 1860, it may be computed that there now passes into the City daily three quarters of a million of human beings, and 100,000 of whom are not on business, but at night leave the City for residential or sleeping population of 113,387; and this vast daily influx is equal to one-fourth of the whole metropolitan population, and equal to the combined population of the parishes of St. Marylebone, St. Pancras (including Camberwell, Jervis's, Hanover-square, Islington, and Lambeth, as they existed in 1861.

Comparing it also with the population on the registration districts of some of the largest towns in the United Kingdom in 1861, it was equal to nearly three times the entire population of Liverpool, more than three times that of Birmingham, four times that of Manchester, and five times that of Glasgow. The increase in the sleeping population up to the present time has been equal to the sleeping population, to more than the total population of Dublin, Edinburgh, and Glasgow combined. And this is the true population of the City, for although not residential, most of its waking existence is spent within the City limits, and it comprises mainly the owners of the City property, and the creators of its wealth, importance, and traffic.

VEHICULAR TRAFFIC.—The great impediment in the streets is owing to the vehicles, therefore consideration must now be specially given to that point. In 1860, the metropolitan population was estimated at 2,269,180; therefore, during twelve of the busy hours of a day in that year, there entered the City a number of human beings equal to nearly one-fifth of the whole metropolitan population. Of these, 100,000 of whom are not on business, but at night leave the City for residential or sleeping population of 113,387; and this vast daily influx is equal to one-fourth of the whole metropolitan population, and equal to the combined population of the parishes of St. Marylebone, St. Pancras (including Camberwell, Jervis's, Hanover-square, Islington, and Lambeth, as they existed in 1861.

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PEDESTRIAN TRAFFIC.—The question of the accommodation for the carriage traffic must always take priority in such considerations as the present, because it is that which suffers most from the want of space, not having, from its very character, the power of adapting itself to circumstances, which the pedestrian traffic has; yet travellers in vehicles in the City are as but one to every three on foot, and almost everyone is at some period a pedestrian in the City; their comfort and convenience will therefore be that much the better if the accommodation for the pedestrian traffic be improved.

The circulation of pedestrian traffic when within the City may be seen by reference to observations made in other places in 1863, when between 8 a.m. and 5 p.m. the following number crossed over the carriageways not having, from its very character, the power of adapting itself to circumstances, which the pedestrian traffic has; yet travellers in vehicles in the City are as but one to every three on foot, and almost everyone is at some period a pedestrian in the City; their comfort and convenience will therefore be that much the better if the accommodation for the pedestrian traffic be improved.

The foot traffic is therefore more vast numerically than the carriage traffic, and its activity and circulation in all parts is more surprising: and although stoppages do not actually take place through the aggregation of the foot traffic, nevertheless the discomfort in some places is upon ordinary occasions considerable, and on wet days (there are 157 days annually upon which rain falls more or less in London) the discomfort is very great.

In the centre of the streets in the centre of the City the footways might be widened with advantage, whilst in others a widening is essential for celerity of movement as well as for safety; and of some few thoroughfares it may be said, that if the whole of the carriageway was turned into a carriageway, it would not more than comfortably accommodate the pedestrians.

COMPOSITION OF TRAFFIC.—Of the traffic generally, some passes through the City on its route to other parts of the Metropolis; another passes through the City for a short stop, but for some time within it; and the largest number of persons are some hours therein transacting their business, or pass the whole day within its limits.

On consideration of the foregoing figures, the vastness of the City traffic, both pedestrian and vehicular, will be seen and appreciated; the considerations hereafter as to the accommodation for the traffic of the City will be understood; and the necessity for extensive improvements will be admitted.

It will also be clearly seen that the traffic which for increased convenience of business in the publicways is needed, is not due alone to the residential population of the City, but is generated mainly by that large section of the metropolitan inhabitants to which the City is a place of daily resort.

In this, however, confined to those, but varies in its constituents, and comprises all classes of society, from the highest to the very humblest in the social scale. Thus there are 68 Members of Parliament who have offices within the City, and are to be found there during the whole period of the year, and many more who combine business interests in the City, even although they nominally have no occupation there. An of that large class who are directors of the commercial undertakings which must have a home in the commercial centre, there are 65 Pére, on the occasions of Parliament, and altogether as many as 559 titled and distinguished personages, whose directorial duties bring them frequently within its precincts.

It may be said, then, that the City is the scene of the daily labour of hundreds of thousands whose homes are in the Metropolis, or even far beyond its broad area, and that within the City are the centres of the industry and commerce of almost the whole country. For although there are other places in England which are the homes of special industries, and of a special commerce, there is scarcely a manufacturer of note, or merchant, who does not either himself reside in the City, or has an agent in the City, and does not at times visit it personally, and it is this combination of interests that causes the vast traffic which daily fills the City.

Yearly this traffic has increased, and yearly it may be expected to increase, for the same influences are operating which have created it; and if it should continue to augment only in the same ratio as the metropolitan population (and it has hitherto exceeded it), then in twenty years, it will be daily in excess of the population, and in forty years a million and a half of human beings; and, therefore, if for the wants of the present traffic alone improved thoroughfares are needed, how much provision should be made for the future! The whole Metropolis, and in a degree the whole of England, is, indeed, interested in this provision being made.

THE GREAT STREAMS OF TRAFFIC.

There are various currents of traffic in the City, but the whole may be said to move chiefly upon two lines—first, that passing between the north and south; second, that passing between the west and east.

These may be subdivided into several smaller streams of traffic, but,
however many the inlets to the City, the traffic entering by them, before it reaches its destination, is nearly certain to mix with one or other of the larger streams. The direction and composition of the several streams of traffic and the conditions under which they are formed, must therefore be inquired into.

The north and south traffic is divided into three principal streams—

which passes over London-bridge; that over Southwark-bridge, and that over Blackfriars-bridge.

some part of the population might go to the river banks and cross over in boats, but the vehicular traffic must pass by the way of London-bridge.

East of a straight line drawn five miles to the north and five miles to the south of London-bridge, are comprised the following metropolitan districts:—On the north side—Bethnal-green, Blackwall, Bromley, Bow, Dalston, Hackney, Haggerston, Hornet's, Horton, Kingsland, Limehouse, Mile-end, Plaistow, Poplar, Ratcliffe, St. George's-in-the-East, Stepney, St. Katharine's, St. Katherine's, Wapping, West Ham, Whitechapel. These districts in 1861 had a population of 697,000. On the south side—Bermunda, Camberwell, Deptford, Dulwich, Greenwich, Lewisham, Rotherhithe, Southwark, Sydenham. These districts in 1861 had a population of 282,000.

The combined population north and south was, therefore, 979,000; and is now probably fully a million, or equal in numbers to one-third of the metropolis. If the roads can be made passable, the Cart-lane might be added to the existing stream of the line, and other parts to the north, south, and east, for which London-bridge is the only highway over the Thames. All of these the population is fast increasing, and in some of them faster than in any other districts of the Metropolis.

The south-west will indeed probably be the home of much of the future industrial population, and the south and south-east will be equally occupied by those who form the great body of the commercial community of London. These will generate a vast traffic of pedestrians and carriages moving vehicles whilst for miles down the river on either bank, docks, warehouses, and manufactories are multiplying and crossing traffic of a cumbersome and slow character.

For the traffic of this great community, already equal to four of the largest roads in Paris, there is nothing but the highway over the river, having a width of carriage-way of 35 feet, and a total width of but 54 feet.

In the year 1860, the vehicular traffic passing over London-bridge between the hours of eight a.m. and eight p.m. was about 18,800, in 1860 it was 16,000, showing an increase of about 23 cent. in ten years.

Now in September 1865, the Brighton Railway Company opened its line to Pimlico, and much traffic which that at time passed over the bridge was diverted, and to this day it continues largely to prevent traffic passing through the City.

In the year 1864, the South-Eastern Railway Company's extension to Charing-cross was opened; that also effected a diversion of traffic from London-bridge, and has continued to do so, inasmuch as at the present time the traffic on the bridge is about one-tenth of the present and Hastings traffic of that railway is booked at the Charing-cross terminus.

New Southwark-street was opened from the Borough to Southwark-bridge-road early in 1863, and to the Blackfriars-road early in January 1864; it gave a shorter and unimpeded route to the west and north-west of London, and immediately developed a large traffic. This traffic in November 1865, had reached 8700 vehicles, which comprised many that would have passed over London-bridge had this new street not been formed.

On the 8th of November, 1864, Southwark-bridge was opened toll-free; previously to that date its traffic had scarcely ever reached 1000 vehicles daily (8 a.m. to 8 p.m.), but it almost immediately rose to 8000, and in November 1865, had reached 4700 during the same hours; this is an increase from 3700 vehicles daily, a very large portion of which was, doubtless, taken away from London-bridge.

Thus we have had the Brighton Railway extended to Pimlico, and the South-Eastern extended to Charing-cross; Southwark-street opened in 1864, and the toll-off toll at the end of the nineteenth and last year; all four causing the diversion of a very large amount of traffic from London-bridge; but, nevertheless, in July 1865, the traffic upon London-bridge was 19,400 vehicles, which was a larger number by 2000 than it was during the same hours in the last year; all four causing the diversion of a very large amount of traffic from London-bridge; but, nevertheless, in July 1865, the traffic upon London-bridge was 19,400 vehicles, which was a larger number by 2000 than it was during the same hours in the last year.

At the present time, the whole line from St. George's Church, in the Borough, to the tower of London with the exception of the wide part of Blackfriars-street, so encountered with vehicles during the busy hours of the day, that it is impossible to proceed along it at a rate of more than four to five miles an hour; whilst between Liverpool-street and Southwark-street, the rate rarely exceeds three and a-half miles per hour, and as the population increases, and the traffic gets greater, this rate of progress will not be obtained.

New Bridge and Approaches.—There is but one complete remedy for the traffic which is the formation of a new bridge or a tunnel, with suitable approaches, lower down the river than London-bridge.

A bridge so situated, with approaches opening for a sufficient distance, both north and south, would not only relieve London-bridge, but would relieve effectually the whole line of street from the Castle Bridge to the Tower, and from the Shadwell Church, the Lord North-street, the Eastcheap, Fenchurch-street, Leadenhall-street, and many other thoroughfares of the City, and would prevent, in a large degree, the conflict which arises between the east and west traffic whenever they cross each other, afford great facilities for business, and an immense accession to a vast and increasing population.

I am aware of the great interests which would be interfered with by the construction of this bridge,—I am aware of the large sum of money which would be required, although I believe that the cost is exaggerated in the minds of most; but whatever the interest may be, and whatever the cost may be, sooner or later a bridge or tunnel must be built lower down the river.

Nothing else will effectually relieve London-bridge at the present day, and nothing else will satisfy the requirements of the vast population which will, within the next forty years, exist east of London-bridge, and it is to be hoped this necessity will be boldly faced at once, and not be postponed until the period when it will cost double the outlay now needed, however great that outlay may be.

The widening of London-bridge by throwing out footways on either side should be avoided. It is physically practicable, although it could only be carried out to the utter destruction of the architecture of one of the finest bridges of Europe; it would not, however, help the difficulty of the traffic, as it is upon the approaches to the bridge on each side that the greatest loss of place occurs. There is a strong opinion that there is the confidence of several streams of traffic: the carriage-ways it is true are, there not quite as narrow as the bridge itself, but they are subject to carts standing to load and unload, which the bridge is not; and therefore, widening these approaches alone would probably go far towards constructing a new bridge with proper approaches.

It is, however, fundamentally an error to make streets and bridges of very great width; large streets are more costly, they are also in one respect inconvenient, they lead to concentration of traffic, and if stopped or impeded (as at times they must be), the public inconvenience is very great—diffusion and not concentration of traffic should be the object in developing the thoroughfares of large towns—alternative lines give the most convenience—and as a principle it may be said that it is far better to have two bridges, each of 50 feet in width, than one of 100 feet in width, even if the cost were greater for the two than the one.

Mr. Haywood examines into the utility of Southwark-bridge, and gives his conclusions:

It is not probable, therefore, that it ever will be so great a relieving London-bridge as the Southwark-street or Bishopsgate-street, as the agency of police regulations enforcing its usage. Nevertheless, situated as it is in the midst of so dense a population, with its ever-increasing traffic, and forming as it does the only highway over the river between Blackfriars and London Bridges, Southwark-bridge should be purchased, and the toll be removed from it for ever.

Indeed, as a principle there ought to be no toll bridge in the Metropolis; directly the necessities are so great that another bridge is needed, it should be built out of the public funds; and with regard to the existing toll bridges, as far as to and including Vauxhall-bridge, they should be purchased, and the toll be taken off as speedily as possible.

It may be desirable to add a few words, specially with regard to the possibility of Southwark-bridge.

If the Corporation should be able to agree with its proprietors as to price, application should be made to Parliament for power to take it compulsorily, and determine the basis of compensation, or the process of it. This is not a difficult matter to arrive at, for it has been opened forty-seven years, yet has never paid one farthing interest upon its original capital, and but one and-a-half per cent. upon its preference capital $2150, nor has it ever been viewed anything but for the traffic that naturally accrues to it cannot be great; its gradients are bad, its width is small, and as years roll on the expenses of its maintenance may be expected to increase. Of the other hand, eighteen months of freedom from toll leaves its present vehicular and foot traffic 2000, and its and its additional traffic 12,900 in the same time (it previously being about 1400 per day); and the toll which might have been due from there would represent an extravagant estimate of its value to the public, inasmuch as it is clear that none of the additional traffic thought

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A NEW STREET NEEDED.—Complete relief can only be afforded by the formation of an additional arterial line of thoroughfare through the City. Nothing else will suffice. The present streets and thoroughfares of the City, and the eastern lines of public way. The formation of such a street, although in itself costly, would render needless many minor improvements, which otherwise must be carried out; would open up and render valuable property in districts now comparatively useless; and would afford additional inducement to the Public to continue the course on which the City is already pursuing, since the inconvenience when other thoroughfares are stopped, enable the agency of the police in the direction of traffic to be largely dispensed with, and would be the best, the most permanent, and certain, in the long run, that can be devised for the improvement of the City.

MINOR STREETS.—Having dealt with the two fundamental wants of the City traffic, which are a new bridge and north and south line, and a new east and west line, the minor requirements must be referred to. No one doubts that, after they have been made, the traffic will be greatly reduced; for, indeed, it may be almost said, there is scarcely a thoroughfare in the heart of the City, which might not be widened and improved with both local and public advantage. Of the subordinate lines lying east and west, Lower Thames-street is gauged for sixteen hours out of the twenty-four, and the same may be said of a large portion of Upper Thames-street during some part of the day; that line of street accommodates, however, its own traffic. The Commissioners have already laid down a line of improvement for it, and it is expected that widening its thoroughfare; a new eastern bridge would relieve Lower Thames-street. The remaining through line east and west is that of Long-lane, Barbican, and Cheapside-street—barrenly sufficient at present, and yearly becoming less so, having the traffic of a busy thoroughfare. The Smithfield will render an improvement more speedily needful, and the whole line should therefore be made fifty or sixty feet wide forthwith. Turning to collateral streets, such as Chancery-lane, Fetter-lane, the other streets leading from them, Flett-street, Holborn, and others, leading between the main east and west lines; the whole are more or less obstructed daily. The same may be said of that large class in the centre of the City, which lie on both sides of the main line running east and west, such as Wood-street, Bread-street, and others. Within the last ten or fifteen years, some of these occasionally afforded relief to the main thoroughfare when encumbered with vehicular traffic; but they are now impeded with that which is due alone to the business carried on in them. Many of them are only wide enough for a single channel. But this alone renders them comparatively useless to the general public.

With regard to the improvements in those streets, but little need be said, as, they will, I believe, mostly be admitted as needful, when I refer to them—and I shall, therefore, simply place them in their proper order, in a subsequent section of the report.

The report then proceeds to treat of the new streets, railways, and other public works now in progress and likely to influence City traffic. The Thames Embankment and its continuation by a new street from Blackfriars-bridge to the Mansion House will ease the traffic of Fetter-lane and Palls-churchyard. Its effect upon Cheapside and the Poultry will be less decided, and it will tend to throw a large amount of traffic into the vortex at the Bank, and in a way that will increase the present confusion. The Holborn Valley Improvement will provide a level thoroughfare in the place of the dangerous hills about which the City authorities were becoming excited so far back as the times which preceded the old Reform Bill. The new Markets in Smithfield will eventually draw all smaller markets of similar character to that spot, and alter the direction of trade and traffic. The City Sewers Commission proceeds gradually with the widening of narrow thoroughfares so far as its powers will allow, and by setting back the frontage of buildings that are pulled down for commercial purposes. Newgate-street, Upper Thames-street, Great Tower-street, Ludgate-hill, and Fenchurch-street are some of the best known instances of works now in progress. The new railways will effect the most important alterations in the direction of City traffic. Of these there are eight which propose to open several new stations within the City, and considering that the area of the City is less than a mile, the possession of thirteen passenger stations, which will exist when these lines are completed, will be a great public convenience. Although several of these stations are rather objectionable near to each other in Liverpool-street, there will be no part of the City more than a mile and very few parts more than a quarter of a mile, from a station.

"The intercommunication between the lines will enable passengers to reach most parts of the Metropolis from any one station; the trains will be so frequent, that no one will think of consulting time tables, and although the speed may not be great, when compared with average railway speed, it will be double that of ordinary omnibuses within a..."
radius of two or three miles of the City. The consequence will be that each station will become the centre which will attract most of the passengers within its radius. The approaches to each of these stations should, therefore, be made adequate, if not already so; but, in most cases, the approaches, when all the stations are opened, will be found sufficient, provided adequate main lines of thoroughfare are made within the city. Therefore, if the main lines of thoroughfare are made generally, it may be said that they will be of the utmost value to the City; they have already supplied a public want, which must have been severely felt, and is manifest from the fact that the railway stations radiate from the heart of the City. And it must be observed that the city companies, being convinced that the great want of the Metropolis was communication with the City, gradually approached it, and at length projected railways within it; and the benefit of these already opened has been so fully appreciated, that no company can rest until it has the same facilities to offer its passengers as other lines—i.e., a necessity which they cannot avoid—and which can never be resisted ultimately. But, nevertheless, with all this convenience, and much as it will distribute traffic, the forming of main streets, and the widening of others, will undoubtedly be necessary. For facility of locomotion stimulates and augments traffic of itself: and thus, without reference to that due to the increase in the metropolitan population, an increased traffic to and from the City may be due to the rapid increase of a population, creating its own business necessities and a corresponding increase of traffic, which will also add to this mighty influx and circuit within the City; and it is this increase, never yet sufficiently appreciated, for which improvements in the City thoroughfares are still more needed.

There is some incorporation of this view in the fact that, in the City, much traffic has been taken away from the City, and at the present time the City railway stations have, as before stated, between 50,000 and 70,000 passengers daily, yet the traffic in the streets has since increased, and vast as the usage of the metropolitan railways generally was during last year, yet the London General Omnibus Company carried 1,357,545 more passengers in 1885 than it did in 1884.

The Report then indicates the improvements which seem to be demanded to meet existing and probable requirements. These are of three kinds, viz., the formation of new lines of thoroughfare, the widening of existing lines, and improvements of a minor character.

For the relief of London Bridge and its approaches, a new bridge over the Thames is recommended. This should be to the east of the Tower, and would need to be connected by suitable approaches with the great thoroughfares on the north and south of the river.

"By a slight variation of its road an almost direct line would be formed between Shoreditch and the Old Kent-road, and the whole of the traffic which lies directly to the north-east and south-east of the City would cross the river by that road; this would include nearly the whole of the heavy dock traffic. There will be no difficulty in forming this bridge with great respect to its cost, and the removal of all the existing great, principally on account of the compensation to the workmen. The wharf property would however not be valuable, even if vacated by its present occupants, and the removal of the special trades now carried on in the warehouses and adjacent premises, even if needful at all, would leave room for the expansion of other business for which the site is adapted, and this would of course greatly reduce the ultimate cost. Billinghgate Market might be transferred to another site if that were found to be proper; and the site of the Crooked Billet, in that quarter, might also be transferred, and the site for a market or fish-market be in the banks of the river at all. The sea-going steamers would not be able to come further up the river than the St. Katherine Docks; but, looking at the facilities which will shortly be afforded by metropolitan railroads, the passenger boat traffic now not be materially affected by such alteration. I however am quite aware that formidable trade interests would have to be disturbed, and that a section of the public must hereby suffer some inconvenience; but sooner or later such disturbance must be faced in order to adapt itself to all the existing great, and by which nothing more. A bridge might be constructed with a central compartment, to open so as to admit the passage of vessels up and down the river at certain stages of the tide; or it might be open to the public for occasional excursion traffic, which are the hours when the great pressure is felt upon London bridge.

A TUNNEL. Another mode would be to construct a tunnel at one of the spots named, but I apprehend that, if really convenient approaches were made, it would be better to have a bridge, nor could it afford the complete convenience which a bridge would give. But the formation of a tunnel which could only be periodically used, or in a tunnel in lieu of a bridge, can only be regarded as half measures—such as have been too frequently carried out in the Metropolis, and which are unworthy of its vast population and of its vast wants. Steam Ferries might be useful lower down the river, but could hardly be used as a means of relief to the traffic of London bridge. For at the spot where a bridge is needed, the river is so crowded with shipping, and the traffic is so great that any additional line of water transport on pontoons which would be necessary could only be attended with very great inconvenience, difficulty, and danger. Steam ferries are, indeed, but the expedients of a poor traffic and a small population. The most numerous of our Metropolis for many years, and I am convinced that the construction of a bridge for ordinary communication across the Thames at or about the spot indicated, will alone materially and permanently relieve London bridge and its approaches both north and south, and that sooner or later such a communication must be provided for by act of Parliament. The relief of the City thoroughfares as respects the east and west traffic is proposed to be effected by means of a new street extending from St. Sepulchre's church, by Newgate, to Whitechapel. This would go to the north of Guildhall and the Bank, and would be a continuation of the line of Holborn, leading in a straight course to the Whitechapel-road. It would also enter the narrow part of London-wall and Wigram-street (which must otherwise be widened) into a broad thoroughfare, and thus in connexion with police regulation it would free Bishopsgate-street within Threadneedle-street of part of the traffic which now encumbers them, and thus aid in dispersing the traffic and in throwing off the terminus of the Eastern Counties Railway being brought to Liverpool-street, as it would be but about 110 yards from that street, where at a future day there will be stations or termini of four different railways. It would also relieve Houndsditch, and Aldgate High-street by opening up a new thoroughfare between the docks and the warehouses in the neighbourhood of Houndsditch. It would ease the traffic to and from all the railway stations lying to the north of it. In respect of distance, therefore, the new route would be superior to the existing one; in respect of gradient it would be the same as that of the old route; in respect of line it would be, for all practical purposes, straight; and upon the whole, therefore, it would be superior to the existing line from Newgate to Whitechapel, being broader, straighter, and shorter in distance. In extending this line of thoroughfare, I propose to throw up public buildings as well as buildings of large commercial importance, but it was found impossible to do so entirely. Its formation would involve the destruction of Christ's Hospital, the Money Order Office in St. Martin's-le-Grand, and several large commercial buildings, and it would cut through a large quantity of miserable property at the extreme east of the City.

Many other improvements are recommended, such as new streets from the southern end of Farringdon-street to Holborn, near Hatton-garden, and to the end of Newgate-street. From near the western end of Upper Thames-street to Ludgate Hill, opposite the Old Bailey, which street should be widened. Many other streets are proposed to be widened, and lay-bys or standing places for vehicles, to be made on the sites of disused churchyards. As to the setting back of projecting buildings which are so inconvenient to traffic, we are told that—"There is scarcely a street in the City which is not very irregular in its lines of frontage, in most of them also there are projections beyond the general line, which are more or less obstructive to the traffic. To remedy this, plans to a large scale should at once be made of all such streets. Lines of improvement should then be laid down upon them, and whenever a building is removed, the new line only should be built upon, and the system should be carried on without deviation. By such means, in the course of twenty years, with the large changes which must during that period take place in the condition of City property, a very appreciable improvement might be made at a comparatively small cost. But to effectual, I repeat, it must be carried out unhesitatingly."

In conclusion, Mr. Haywood alludes to other matters bearing on the question of street improvements, and of general interest to the inhabitants of the Metropolis. He says—"I have endeavoured to suggest improvements commensurate, not
only with the present wants, but also with the necessities of a future population, as, undoubtedly, a portion of the expense of present improvements, by future development of the half-measures, or such as are merely palliative, the results of which may perhaps be scarcely felt a dozen years hence, would not be sufficient, nor would it be just to those who may hereafter have to pay largely for them, and they have sacrifices upon their own account, the same extravagant character, and, in two cases, such as will go far to meet the requirements of a great augmentation of the metropolitan population; and especially in the interest of the future population these improvements should carry out at once, for fifteen or twenty years hence they will cost double what they now would cost, great as the outlay might be.

Exigencies in respect of highways will soon also arise in parts of the Metropolis far off from the City, and the formation of lines of thoroughfare, particularly in the centre of the Metropolis, is one of the most important measures by which the public convenience shall be promoted. This is not a matter of urgency in the existing suburbs, as for the time being, but the line should be selected, and the actual expenditure made. The progress of the Metropolis doubles itself in forty years, and that the traffic towards the centre appears to increase in a greater ratio; so much so, indeed, that I firmly believe that the improvements I have herein suggested, large as they may seem to be, will not be adequate to the wants of the City by the time the metropolitan population is doubled.

In drawing up this report, many incidental subjects have naturally suggested themselves to me, upon which I beg to make a few remarks.

Highway Traffic.—Considering the advantages which the river route between the east and west part of the Metropolis possesses, it is surprising that no successful effort has yet been made to regulate the steamboat traffic as to obtain the full measure of benefit which it is capable of affording. Steamboats should be encouraged by law to use steamboat piers, yet there is scarcely one approach to them that is sufficiently public and sufficiently convenient, and this is the first thing in which improvement should be effected. The boats themselves are not provided with a handsomely clean, and convenient kind which should be made compulsory, and which would render them attractive to passengers and an ornament to the river, as well as more renumerative to their proprietors than they can be in their present unsatisfactory condition. There are two conditions of the river which, if both are improved, a larger steamboat traffic might be developed, with advantage to the public, and benefit to the proprietors.

As to the Formation of New Streets.—The formation of a new line of street is frequently opposed by those owning property or business in the existing main lines, upon the supposition that the diversion of the traffic will be injurious to their interests. Should this even be the case, it must be observed that no individual has a right in the public traffic; and, moreover, when the traffic reaches such an extent as to create a public nuisance, a public interest is invaded, and is generally foreseen and calculated upon many years before it takes place. In the majority of cases, however, no fear need be entertained of injurious consequences, for it is rarely that any street improvement is carried out in the manner, unless the sufferers for want of profit have a sufficient improvement; and at the present time the impeded condition of the main lines of City street, is undoubtedly a hindrance and impediment to the business within them, and the diversion of some of the traffic could not therefore be otherwise than a benefit to all; for every facility of intercourse with the City which is afforded to the metropolitan population, has a tendency to increase the traffic and increase the business. And the actual business in the streets so relieved in all probability will be greater after the relief, than it is at the present time.

When new lines of streets are planned in the Metropolis, it has frequently happened that they are spoiled at some point by obstacles which should not be allowed to interfere with them; the impediments are usually the existence upon the proposed lines of public buildings, or the private buildings of people who have purchased in the expectation of influence, or they are the result of some small economy practised in the midst of a large expenditure. Such influences it is believed brought the northern end of Regent-street to its ugly junction with Portland-place. Indeed, the whole line of the Embankment, from the Regent's end; now prevents the formation of the very best line of access from Trafalgar-square to that noble thoroughfare, and will leave in the middle of the new street from Blackfriars-bridge to the Mansion House, which is to be a thoroughfare for forty years with a width of about 50 feet. In the City, the chief obstacles formerly were the churches, which, being numerous, were in the way of every line of street which was projected. In some cases they were removed, as for the formation of London-bridge and its approaches, and the streets in the vicinity of the new station, but not quite so satisfactorily as one would wish; as good satisfactions for a use of this thoroughfare were formed. But where they were allowed to remain, and the streets were planned so as to avoid touching them, the thoroughfares have been utterly spoiled, of which an example is Gresham-street. The churches are still almost as numerous as ever, and are so situated that in every direction they prevent local improvement, and it is almost impossible to plan a new street or to improve an existing one so as to avoid them. But for a large and important improvement there would perhaps be less objections, and the adverse sentiment of Londoners is far from the case, for it has been shown that the residential population is decreasing, and the congregations in most of them will become less and less; and therefore new lines of thoroughfare in the City should not in the future be judged by the standards of the 17th and 18th centuries. Never-
CRYSTAL PALACE, SYDENHAM.

Roof of Centre Transept.
Span 120 Feet.
ROOF OF NEW MARKET HALL, DERBY.

Fig. 1.

Scale for Fig. 1. — 1/6 Inch to a Foot

Fig. 2. — 1/12

Fig. 2.
AMSTERDAM CRYSTAL PALACE ROOF.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Scale of Feet.

0
10
20
30
40
50
The parapets are carried by it in these intervals. They consist of simple iron 6 inch x 3 inch x ½ inch with an available section, and are joined in lengths of 21 ft. 9 7/16 in. between each pair of main ribs by two joint plates 2 1/2 inches long, 6 inches wide, and ½ inch thick, and twelve ½ inch rivets. These parapets carry the W. F. skylight bars, one length of the former divided into twenty spaces gives the distance of each skylight bar about 18 inches long, with the left edge of the roof on the first and last 1/8 inch braced horizontally, to resist any strains that may be caused by the pressure of the wind either on the gable or on the side.

Ventilation will be supplied for by open spaces in the skylights, along the whole length of the ridge, and also along the eaves where the glass overhangs the gutters. The lower portion is ventilated with the roof, the narrow skylight, at right angles to the ridge, 152 feet wide, extending nearly the entire length of the roof, there will be a gap at the top of each skylight along the whole length of roof, and each gutter of skylight will have a snow grating along its whole length, with cross splices to enable the workmen to repair and clean the glass. The portion of the roof below, is partly taken by the heavy brick piers, which act as abutments, and partly by a wrought-iron tie running below level of rails across the platform, forming one of the wrought-iron girders supporting the latter one.

Referring to the various roofs described, we find that in the Dublin Crystal Palace Roof, with a clear span of 49 feet, one square of area covered with glass requires 2½ cwt. of wrought and cast iron. The smaller roof of the Crystal Palace, with a clear span of 58 feet, a square of covered area with glass requires 13 cwt. of wrought and cast iron. The Derby Market Hall roof, of the same clear span, and partly covered with glass, requires 15 cwt. of wrought and cast iron. In the large roof of the Crystal Palace, which has a span of 104 feet, a square covered with glass requires 12 cwt. of wrought and cast iron. In the Amsterdam Crystal Palace Roof, which has a clear span of 63 ft. 2½ in., an area of one square covered with glass requires 15 cwt. of wrought and cast iron; and, lastly, in the Midland Roof, of 340 feet span, one square of area, covered partly with glass and partly with slate, requires 17 cwt. of wrought and cast iron.

In each of these buildings covered by these roofs we find a new principle employed in the construction of ribs and in the arrangement for taking the horizontal thrust. In erecting true arched ribs, it will be often the case that the feet of them must be made to spring out a little to fit the supporting structure; but it must be considered then, on the other hand, that in all cases the flanges are constructed stronger than minute calculation would require, and so the pressure may be increased a little in the top flange at or near centre, getting lessened at the same time in the bottom one, and that without any bad effect upon the structure itself. The Amsterdam ribs were, in fact, manufactured so as to spring out in erection 2½ inches, as already mentioned in the description.

The most rigid of the above is the Midland Roof, which is a square, and the principal will be the Midland Roof, so as to stand upon the structure itself. The great weight, therefore, of the Midland Roof is a guarantee for its stability. This is shown to a certain extent by constructing the curves of equilibrium for the equal load and the unequal moving load, the vertex in the latter case not moving as much as it would in the case of a smaller, and consequently lighter, roof.

No apparent provision has been made in any of these roofs for expansion of the structure by temperature, as is commonly done in large roofs where trussed principals are employed. As the abutments are not allowed to give way, the ribs will simply rise and fall at the crown like the iron arc of a bridge.

PROPOSED ROOF OF THE ST. PANCRAZ STATION, MIDLAND RAILWAY.

Although the particulars of this roof have been already published it was still thought advisable to repeat them here again for the sake of comparison. The area covered by this roof is 600 feet by 57 feet. The main ribs are 29 ft. 4 in. centre to centre, and have three intermediate ribs between them at equal distances apart, carried at every 18 ft. 6 in. by trussed purlins between the main ribs. The form of the ribs is entirely novel. They spring directly from the ground, and are firmly connected to massive brick piers below. The curve of the ribs is of two radii of 180 feet and 57 feet, meeting at an angle in the centre 100 feet above the level of rails. The ribs are 8 feet deep, and formed with open box flanges 10½ inches deep; the flanges being braced together by diagonal channel irons and radial struts forming the ends of the purlins. The frame is therefore sprung at the top of a height of 29 feet from platform level. The purlins are constructed of plates and angle irons rivetted together.

The intermediate ribs are 10½ inches deep, and will be made most probably of angle iron braced with diagonal bars. The purlins are braced beams 18 ft. 6 in. apart. They are so constructed that they stiffen the main ribs laterally. The bracing is so arranged as to carry the proper proportion of each of the three intermediate ribs, besides assisting to keep the bottom flanges of the main ribs in place. The floor of the roof is braced horizontally, to resist any strains that may be caused by the pressure of the wind either on the gable or on the side.

The LATE GEORGE RENNIE, F.R.S., C.E., &c., &c.

It is our painful duty to record the decease of the above named eminent engineer. Mr. Rennie had been comparatively an invalid for some years prior to his death, which event took place on Good Friday last, March 30th, at his residence in Wilton-crescent, London. It would be difficult, if not impossible, to mention a name connected with the civil and mechanical engineering professions of this country more distinguished than that of Rennie. Monuments exist on all hands which will testify to posterity of the indomitable industry and the genius of the founder of the house—John Rennie—whilst his descendants have proved themselves worthy of their sire, and achieved also an
enduring reputation. Our present object however is not to trace out and chronicle the numerous works which made the life of the first Rennie remarkable, but to indicate rather some of those which have tended to make famous that of his eldest son—the subject of the present memoir.

George Rennie was born at the village of Christchurch, in Surrey, on the 3d of December, 1791. His father had then been established as an engineer in the Metropolis for about seven years, and in friendly union with Messrs. Boulton and Watt, who had early discovered his great ability, he had achieved considerable fame. The education of young Rennie was commenced at the classical school of Dr. Greenlaw at Leicesthorpe, and continued at St. Paul's School. At seventeen Greenlaw himself would have been said to have received his first lessons in engineering, for he then accompanied his father in one of his annual professional tours through England, Ireland, and Scotland. The advantage of this first insight into the mode of conducting works such as those under the management of the elder Rennie was great, but it was supplemented, by introductions to men of eminence—scientific, scholastic, and practical; and it is known that the journey was productive in all ways of excellent results to the youth.

Soon after this memorable tour it was determined that George Rennie should be entered as a student at the College of Edinburgh, and this was speedily accomplished. The Rev. Dr. Roberts was his first tutor in the Scottish capital, and with that gentleman he remained for two years, having also the privilege of daily communication with Professor Dunbar, and Dr. Henery, the celebrated chemist of Manchester. At the end of the period named his father possessed so large a fortune that he engaged the services of Professor Playfair, in whose house he resided for other two years, and under whose guidance he profited greatly. Professor Playfair was admirably qualified to be the guide and friend of youth; and in the present instance he found an apt and intelligent pupil. The latter was most assiduous in the pursuit of information, which the former possessed in a remarkable degree the valuable faculty of pleasantly imparting it. During the time that young Rennie was thus happily situated he attended classes for the study of all those branches of knowledge an acquaintance with which was considered likely to be of most value to him in the future, mathematics, natural and moral philosophy, Greek and Latin, &c.

By the year 1811, it was considered that he had acquired sufficient book-knowledge to fit him for more practical labours, and he then returned to London. In the drawing office, and the workshops of his father's establishment at Blackfriars, we next find the subject of this memoir. In both departments his dexterity and amiability of disposition were most strikingly displayed. He is reported to have made at this early period of his life the working drawings for a small steam engine, and afterwards to have fitted up the engine unaided by other assistance. Unhappily, this specimen of his youthful ability and perseverance was destroyed, many years after the fact, in a fire which occurred at the manufactury of George and Sir John Rennie, in Holland-street.

In 1818, he was appointed Inspector of Machinery, and Clerk of the Irons (dies) at the Royal Mint, London, in succession to Mr. James Lawson, deceased. The office demanded that its possessor should have a practical knowledge of machinery, and of the character of steel, and was otherwise of an arduous nature. The appointment, on the strong recommendation of Sir Joseph Banks and James Watt, was confirmed by the Treasury, and for eight years subsequently Mr. George Rennie was a Government Officer. It does not appear that the occupation was congenial to him, for in 1821 he retired from it, and returned to his old quarters at Blackfriars. During what may be termed the official portion of his career, it was the misfortune of Mr. George Rennie to lose the counsels of his father. In 1821, and in the 60th year of his age, John Rennie died, and then it was that a partnership was entered into between the two sons, George and John (Sr.), and with whom the father's death may have conduced to the abandonment by the former of his post in the Mint. Vary speedily the heads of the new firm imported a considerable amount of energy into the conduct of the business which had thus been committed to their charge. Their father had left many designs for public works, and especially among these were the bridges of London, Southwark, Staines, and that for spanning the serpentine in Hyde Park. All these were afterward realised by the younger Rennies, as well as many other structures of a similar but less important character in various parts of the kingdom. They took care to associate with themselves talented assistants to conduct, and skilful workmen to execute the various undertakings for which they were responsible, and hence another source of the invariable success which attended their labours.

In the construction of the vast Docks of London, Leith, Sheerness, Dublin, Deptford, Chatham, Woolwich, and Pembroke, and in the formation of the harbours of Plymouth, Howth, Kingstown, Portpatrick, Ramsgate, and Whitehaven, they gained great fame. The Plymouth Breakwater, and the magnificent Victualling Yards of Plymouth, sixteen years of construction or so, are also among the works demanding honourable mention.

The drainage of the fens of Lincolnshire, Cambridgeshire, Bedfordshire, and Norfolk, though less prominent as engineering works than those referred to, were productive of great advantage, and the results attuned the skill and energy of the Rennies.

In the department of Civil engineering the late George Rennie distinguished himself greatly. To him was entrusted the first survey of the present Liverpool and Manchester railway. He had prepared himself for it, by numerous investigations into the working of the railways in the northern and western parts of the kingdom, and notably of that between Stockport and Darlington. In the years 1825-26, he had also made a vast number of experiments on the gliding and rolling friction of metals and other substances. Briefly it may be said that the act for constructing the "line of the Liverpool and Manchester railway, as laid out under the direction of Messrs. George and John Rennie, was passed 5th July, 1825."

Mr. George Rennie also made the survey of the London and Birmingham, the Great Northern, and many other accomplished or projected English railways; the Namur and Liege and the Mons and Manege lines in Belgium were surveyed and partially constructed by him, and the remarkably beautiful stone bridge over the Rhine at Aiachus, which it was designed by the same gentleman. The present bridge at Chester, originally designed by the late Mr. Harrison, was completed by Mr. Rennie, who exhibited great ability in the construction of the centring employed in its construction. It was the fortune of Mr. Rennie to be frequently called upon by foreign governments to construct machinery for almost every conceivable purpose. We can scarcely enumerate the number of machines which owe their existence to his mechanical skill. Those of Calcutta, Bombay, Lisbon, Mexico, Peru, and France may be cited. In the formation of the machinery for these he found the knowledge of coinage, which he had acquired in the Mint, of great service. In working his designs of old, with the firm of Messrs. Boulton and Watt, he has certainly rendered the names famous for their money factories.

As a complete and perfect specimen of mechanical work, for a totally different purpose, the Turkish Small Arms Factory, situated at the Susur Castle, can hardly be referred to. It was designed by Mr. Rennie, for the manufacture of 100,000 muskets per annum, and comprises the whole of the appliances necessary for forging, rolling, rough and fine boring, adjusting, and proving the barrels, the forging and fitting of the different parts of the locks; cutting and shaping the stocks, &c. During the progress of the Crimean war the establishment was in full work, and produced the maximum number of muskets for which it was originally designed, it thus proved of great service to the Turkish Government. Similar machinery was afterwards completed for the arsenals of France, at Chatelbeaux, Toulon, and Rochfort. By the Russian government Mr. Rennie was highly esteemed; for some years he held a seat in St. Petersburg during the siege of that gigantic fortress and stronghold. The latter was indeed the first screw steam-ship introduced into the Russian service, and she was followed by the "Peterhof" and "Alexandria," used as yachts by the late Emperor Nicholas. Other steam ships of lesser note were fitted out for service in the Black and Caspian seas. Mr. G. Rennie designed the Great Steam...
FORMULAE FOR OBTAINING THE STRAINS ON THE SEVERAL PARTS OF GIRDERD AND ROOFS.

By ALFRED A. LANGLEY, C.E.

Let any triangular combination of bars, such as is shown in the annexed figure, be loaded with weights \( w_1, w_2, w_3 \), &c., at the point of junction of the intermediate and upper bars. Find the weight or reaction at the support \( A \), owing to these weights, which call \( R \). Let \( S \) equal the strain on any of the lower bars in the direction of its length, which strain we shall now proceed to find on the bar \( FG \). Draw the line \( ED \) perpendicular to \( FG \), and through the point \( D \). Let the sum of the weights between \( D \) and the support \( A \) be called \( W \), and let the horizontal distance of its centre of gravity from \( D \) be called \( g \), also let \( d \) equal the horizontal distance between \( A \) and \( D \). Then taking the moments about the point \( D \) we have

\[
S = R \left( \frac{d}{DH} - \frac{W}{DH} \right)
\]

By the above process the strains on each of the lower and upper bars may be obtained; the upper bars will be in compression, and the lower ones will be subject to a tensile strain.

Intermediate Bars.—There are four bars meeting at each of the points \( E, F, G, \) &c., their directions are known, and after obtaining the strains on the two lower bars by the preceding formula, the forces acting on the remaining two intermediate bars can be calculated by properly resolving the forces so that they may be in equilibrium.

The forces can readily be arrived at by construction as follows:

Let the inclination of the bar at the meeting point \( F \) shown in Fig. 2 by the lines \( EF, CG, \) and \( DF \). On the lower bars set off distances \( FJ \) and \( FK \), representing the strains on these bars. Produce the line of the bar on which there is the greatest strain, which we will suppose to be \( JF \), draw a line from \( K \) perpendicular to \( EF \), and intersecting it in \( I \). Set off \( JN = FI \), draw \( LS \) through the point \( N \), perpendicular to \( JF \),

* It is proper to mention in connection with this part of our subject that Mr. Rennie's exertions after his construction of the well-known steam- vessel the Archimedes is due, partly, to the association into the work of Mr. Rennie's a strong advocate of the screw propeller when many other engineers declined to enter the field of employing it at all, and when Mr. P. F. Smith, the other ingenious men, stood in need of supporters.
and draw a line parallel to El from K, intersecting LS in T; then will TF be the resultant of the forces acting on the intermediate bars; but by the lines clear to EF and FC, intersecting them in O and V, then will FO and FV represent the strains on FC and FD respectively. When T lies between the intermediate bars they will both be in compression, and when between the lines of the intermediate bars produced below F, both in tension; but if the resultant is not in either position, then the bar nearest T will be in compression, and the other in tension. Let the strain on EF and FK = H and h respectively; also let the angles CFE, CFD, and DFG = α, β, and θ respectively, and the required strain on CF = x and on DF = y; we can then at once write down

\[
\begin{align*}
\sin(\alpha - \beta) + \frac{x}{\sin \alpha} &= +H \\
\sin \beta &= \frac{x}{\sin \beta} \\
y &= \frac{\sin(\alpha + \theta) + \frac{y}{\sin \alpha}}{\sin \beta} + \frac{H}{\sin \beta} \\
\end{align*}
\]

BELFAST WESLEYAN COLLEGE.

The foundation stone of this college was laid in the autumn of last year. The building, which has now made considerable progress, will be in the Gothic style, of the usual academic type—the details Early English in character. It comprises a longitudinal main building, 190 ft. long, with two transverse wings, each 130 ft. in length, projecting both to front and rear. In the centre are a main projectory hall, and the main building. A terrace or terrace in front will be laid out in ornamental beds and walks. There is also a central rear building, containing the refectory, kitchen, laundry, and offices. The college is to serve for two distinct purposes, namely, a theological college and a preparatory school. The left side of the building is devoted to the school, the right to the school, the departments common to both occupying the centre.

The principal entrance and the president's house occupy the centre of the front; the theological tutor, on the left, and the head-master, on the right, have their residences in the main building, each having a separate entrance. At one side of the principal entrance is the waiting-room and board-room; and at the other the president's hall and staircase, also his study and dressing-room. The rest of the president's, tutors', and head-master's apartments are in the basement and on the first-floor of the front building. Each house is perfectly distinct in itself self-contained. Behind the entrance-hall a corridor or cloister leads right and left to the school-room and lecture-hall, which form the front projecting wing, each about 55 ft. by 27 ft. in clear. The lecture-hall has a partially open roof, with semicircular ribs to the principals, and ornamental pierced boarding filling the spandrels. The school-room is 20 ft. high, and has a dormitory over.

The total number of students to be accommodated is 20; of boarders, 80; and of day pupils, a little over 100. A separate entrance is provided for the students, and one for the boys, in their respective staircase towers. These latter form a good feature in the design. To the lecture-hall a distinct entrance is provided for the admission of the public, on the occasion of lectures, distribution of prizes, &c.

The rear projecting wings contain the class-rooms and the library of each department, with dormitories over. The rear central building is connected with the main building by a central staircase, with two side passages to the dining-room, which measures 60 by 25 feet in the clear, and has an open roof. In one corner is a recess containing a lift communicating with the kitchen, which is immediately beneath. To the rear of the dining-hall are placed the butler's pantry, matron's rooms, stores, &c., with a back entrance. The main kitchen, sculleries, servants' rooms, and minor offices, are in the basement. The rear projecting wings are so planned as to be capable of further extension.

Extending over the residences, the students' bedrooms occupy a portion of the second-floor of the front, a separate room being given to each. Large dormitories, extending over residences and school-room, are provided for the boys, in some of which the system of division into cubicles is adopted. Separate bed-rooms for the under-masters are placed in immediate connection with the boys' dormitories. Water-closets, lavatories, and bath-rooms, in proportion to the number to be accommodated, are provided in suitable places.

A principal feature in the design are the stone staircases in the side towers give access to the upper floor. The first-floor of the building, at the rear of the dining-hall, at one side contains a hospital; at the other, apartments for the matron and female servants, each side approached by a separate staircase. The building is intended to be of Belfast red brick, with dressings of freestone from Glass- oglen, near Derry. The overhanging eaves between the first and second story are in part carried on consoles of the architectural type, and the wall hanging in the basement is of the freestone of the locality.

It is intended for the present to omit a portion of the wings.

The cost of the building, as now contracted for, will be £11,000. The architect whose design, selected in a limited competition, is being carried out, is Mr. William Fogerty, of Dublin. The builder is Mr. James Henry, of Belfast.

Ipswich New Town Hall.—The foundation stone of this building has at last been laid. The works are being carried out under the direction of Messrs. Belasyse and Hardy, architects, the contract amounting to £11,700, being taken by Mr. E. Gibbons, of Ipswich, and the masonry is being executed by Mr. R. Ireland, of Ipswich. Mr. W. P. Ribbans, the borough surveyor, and Mr. E. Catchpole, act as clerks of the works. The building has now so far progressed as to be in some places complete, so as to be thrown above the level of the street. On the ground floor is the Vestry. The principal front towards the Cornhill is divided into centre and side wings. The centre is composed of three canopied openings surmounted by a tower and clock turret, with illuminated dials. Balconies are provided in the first or principal story, from which public meetings held on the Cornhill may be addressed. The wings on either sides are divided by vermi-

culated pilasters, forming arched and deeply recessed bays for windows. Red Mansfield stone will be used for the plinth of the building, and the columns and the pilasters throughout. The principal staircase will also be of red Mansfield stone. The height of the building from the ground to the top of the architecture is 65 feet, and to the top of the tower will be 100 feet.

Status of James Watt.—A statue of Watt is about to be erected in Birmingham. It will be in marble, and 8 feet high. Mr. A. Munro is the sculptor.

New Dock Works, Sunderland.—The bridge across the junction entrance, being the first portion of the work in connection with the new Hindon Dock, was opened on the 26th ult., by the chairman of the Commissioners of the River Wear. The bridge, which is of iron, is lifted off its supports by means of a hydraulic press, it works on a water centred beneath the pivot of the bridge, after being lifted about 2 inches, it is swung round by means of handles attached to each wheel. The total weight is about 100 tons, its length about 112 feet, span 90 feet, its breadth 12 feet 6 inches, depth of outside girders 2 feet 6 inches. The bridge on being swung round worked admirably. These dock works, which have progressed most favourably since commencement, two years ago, are expected to be ready for opening throughout on the 1st October next. They are from the designs and under the direction of Thomas Merk, the Commissioners' engineer; Messrs. Sir W. Armstrong and Co., Newcastle, being the contractors for the machinery.

A new Church at Pawley, Oxon, was consecrated on the 12th ult. The style of building is early medi eval, and it consists of nave, aisles, chancel, and circular apse. The roof of the chancel is composed of groined stone. The roof of the church is open timbered, and the walls are of stone from Bisham common, near Cirencester, hammer dressed. The pillars are of highly-polished Devonshire marble, with carved Bath stone capitals. The reredos is by Earp, of Lambeth, from a design by Mr. G. E. Street, the architect; it consists of three compartments, the centre panel containing the Crucifixion, and filled in with mosaics. The font is richly ornamented with the most costly kind of marble as the pillars. The floor is laid with encaustic tiles by Godwin. The seats are open and of carved oak, and offer accommodation for about 200. On the north side of the chancel stands the organ, which was built by Hunter, of Kennington-green. The whole of the works were carried out by Messrs. Rogers and Booth, of Compton, the duties of clerk of the works being carried out by Mr. Cloutman. The cost of the structure, independent of the site, was about £3000.
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

THE ARCHITECTURAL EXHIBITION.

The Architectural Exhibition opens this year under somewhat different auspices to formerly. It is now denominated a Society, having a president, four vice-presidents, and the ordinary council or working committee, with the usual officers. The president is Mr. Beresford Hope, who is also the president of the Royal Institute of Architects. Amongst the other officers are the late two secretaries, Messrs. Ferguson and Edmeston, whose places in the latter capacity are now filled by Messrs. W. W. Edis and Rowland Plumble; while Mr. Ashpitel has resigned his honorary treasurership, and been succeeded by Mr. E. B. Lamb.

In addition to the president's opening address at the inauguration of the new exhibition, held at the Institution of Engineers and Shipbuilders on the 1st of May, lectures have been delivered during the month of June, viz:—May 15th, by Mr. Digby Wyatt, on "The advantage of travel in the study of architecture;" 22nd, by the Rev. J. L. Peilt, "Remarks on Egyptian architecture;" 29th, by Thomas Wills, Esq. On the influence of Eastern on Western Architecture. In the latter, however, little attention is devoted to the influence of classical buildings. The usual privilege is accorded to season ticket holders, of admission to these lectures, as well as to the exhibition at all times when it is open; and this is a great boon to all who can avail themselves of its full advantages, the charge being the almost nominal one of half-a-crown.

It may be also presumed that some alterations have been made in the arrangements of the galleries themselves: the two principal apartments being now confined, as originally, to architectural drawings and architectural photographs only, while the eastern gallery has been reconstructed internally, and is now filled with a useful collection of practical works in connection with the general subject of "Building Materials and Appliances," under the management of Mr. D. O. Boyd. The north gallery is still retained for sundry general features of the same kind.

The absence of one familiar face will not be regretted by all who were acquainted with the genuine worth of the late councillor Lamb, as well as to the other and more especially on that account to the interests or comforts of whose whom it was evidently as much his pleasure as his duty to serve, and whose sudden removal by death, a few months since, is a loss consequently felt far beyond the circle of his family and connections. I have nothing to add, with satisfaction that we learnt that the post had been offered to, and accepted by, his nephew, Mr. W. Farthing, a gentleman whose business qualifications in every way fitted him for the work.

Mr. T. Anson (1) exhibits his new building in New Southwark-street for the Hop Planters' Company, a plain red brick edifice, of the warehouse type, rather less ornate and characteristic than the majority of that gentleman's works. Mr. C. E. Giles has some excellent drawings of buildings in progress, carefully given, though perhaps to rather too small a scale. However, as each is shown by more than one view, there is less left to be imagined than there otherwise would be. Of the half-dozen groups thus exhibited, the most noteworthy are (8) "a church and curate's house at Nordeiph, Norfolk;" (12) a small new "church and schools at Froome Selwood," which are designed with much true feeling, though the bell-turret to the former is rather too pretentious for the general character of the rest. Mr. C. E. Perry's studies are properly too—the effect of skylines, and the forms of his roofs. Foremost among the sketches of old buildings must be mentioned those by Mr. T. H. Watson, of which several were made by him during his travelling-studentship of the Royal Academy are distributed on the walls. His rapid and effective and even delightful sketches as to the masonry and rendering these sketches (for such they in truth are) very every expressive and satisfactory to the beholder. In this category may be particularised the exquisite porch to "S. Paolo, Ferrara," (2), and S. Matthius, near Treves (4). A brother traveller in the same school, Mr. Phenot too, has made some excellent class, more travelled, but generally less effective than those to which we have just referred. His sketch of the "Cathedral of Palermo," (23), and the "House of the Painted Capitols, Pompeii" (23), will be especially examined with interest. As a specimen of patient labour, in illustrating a subject of interest which do not remember being specially put in the old manner, treated, we may point to (6), Mr. R. Groom's elaborate drawing of the "Old Choir Gates of St. Paul's Cathedral." In (8) and (7) Mr. Plumble exhibits an interior and exterior of a proposed "Congregational Mission Church, North Bow," the former of which has some very good features, particularly in the construction of the arches, which for a church of this character appears of the same order as that of the latter. For the most part, consisting of ornamental curved ribs and braces, connected by a tie beam, not at the usual wall-plate level, but at about one-third of the space above.

Passing by Mr. Whichcord's "Offices in the Old Jewry" (16), which are very fine, do not we find "Parsonage Houses," adjoining (30), which completely kill everything near them. Yet this is no undesirable attainment in these competition days; and Mr. Hooker may deem himself very fortunate in having at command so skilful an artist, whose abilities have undoubtedly been also exercised in tinting Mr. Borough's local character, which is said to resemble more the picturesque artist than the genuine architect, nevertheless there are in both of them many good points of composition as well as detail. Mr. W. Peachey is a conspicuous exhibitor, not only of his architectural productions, but of his peculiar features, which are set forth in a way that would be a contrast in an illuminated border, as a cento to a "Sheet of Photographs" (179), which would otherwise be probably overlooked altogether. Nor are the drawings (39, 66) of his competition design for the "Exchange at Middleborough" more commendable, betraying as they do but little appreciation of the real secret of true art. Thoroughly contrasted with such attempts (and their name is legion) are the really clever and artistic conceptions of Mr. E. B. Lamb, who, as heretofore, is a liberal contributor to the exhibition. We must still, however, except the peculiar style in which he continues to invest his churches, which savours more of the domestic of an age than the orthodox secular character. His "London Street" and "Street in a Sussex village" are picturesque in the extreme, and show the well-trained hand of a master mind. See the photographs of Nuneatponot, Yorkshire (42), and of the Manor House, Aldwark, near York (191), also Parkfield Place, Fawkham, Kent (78). The "Broad Street, Norwich," School," by Messrs. Austin and Johnson (46) are in character with the old building, a good example of plain domestic Gothic of the Perpendicular age. In their new church, too, of St. Stephen, Henwaco-Byes, shown in an exterior and an interior view (76, 82), there is the same correct appreciation of style, plainly but sensibly treated, especially in the masonry and the window views.

Before us we have Mr. A. G. Walker's "Middleton Bridge," which is a complete study in its own way (80 and 81) are two large frames of photographs, the former, by Mr. Phipps, of Bath, exhibits the Millit Store, Gateway, New House, &c., erected by him in that city for the 2nd Somerset Militia, and also portions of some semi-detached villas of careful design; the latter consists of no less than fifteen reductions from drawings of buildings designed by J. P. Noon and others, and some very extensive and expensive commissions are further displayed in (204 and 224), besides a series (217-220) of "Madrid Improvements," gigantic in scale, and satisfactory in appearance, provided they meet the requirements of the climate, which is perhaps open to query. There is too much prettiness about Mr. J. P. Noon'sestates design to render it entirely suitable, but the sketches (47, 48); while the extravagant attempts at quaint originality in which Mr. Bassett Keeping delights to indulge are far less tolerable. Of late there have been symptoms of a subdued tone in this gentleman's works; and his Wesleyan Chapel at Dalston (30), in its details, and especially the chapel-keeper's house under, costing inclusively, as stated, only £200, has really considerable merit; but the best of Mr. Keeping's executed works, so far as we know, is his "Church of
St. Philip, Camberwell," of which a complete series of plans, sections, and elevations, is given in (175-176); though the overhanging of the complete belfry stage is not altogether judicious. 

Mr. Moccata, in his Italian sketches, has supplied an interesting study; those from Milan Cathedral (91) especially. Nor should his " View at Amiens" (242) be overlooked. The greater part of the church of St. Cuthbert, Darlington, has been restored, we believe, by Mr. Pritchett of Darlington. Mr. Pritchett shows his characteristic touch at the east end, as recently restored by himself. This church is well known as one of the finest examples of early work in the north of England; and it is gratifying to know that to a very threatening condition, it has been made thoroughly sound, and restored, as far as possible, to its original aspect. 

In the interior of the new proscenium of the theatre at Nottingham, Mr. Holliday has depicted Shakespeare, with the principal characters from his comedies and tragedies, forming part of an architectural composition designed by Mr. C. J. Fipps, and here shown in a coloured photograph (98); the same frame containing views of the interiors of the theatres at South Shields and Nottingham. (101) Contains five photographs of recently-erected buildings by Mr. Thomas Harris; the originality in which partsake quite as much of mildness as is displayed in most things of the kind, too often wildly novel and proportionately unsatisfactory. "The Vicar's House, Lowestoft," in this series, is a notable instance.

In the large gallery, the first subject is "The building designed for the International Exhibition, Bombay," by Mesers. Imbeshaw and T. Roger Smith, shown in a cleverly coloured interior view (118), while (249) gives an exterior view of the same building. In the drawing, though the extraordinary novel, of the ordinarily received type of such edifices, particularly in the application of iron and glass, the modifications necessary to suit local exigencies have not been overlooked, and consequently there is an air of truthful novelty in the general aspect, which is very satisfactory. But by far the most important drawings in the room, and indeed in the whole collection, are those contributed from the recent competition for the New St. Pancras Station and Hotel for the Midland Railway Company, in the Euston Road. The designs which received the first and second premiums are exhibited at the Royal Academy, but there are here before us (taking them in the order of the catalogue) portions of the designs of Messrs. J. F. Cockerell, Owen Jones, and T. C. Sotheby. That of Mr. Cockerell includes the general plan, but as it is hung above the eye, it cannot well be adequately examined. Considering, however, the magnificence of the scheme, the general arrangement seems dictated by the site, and one which, probably, most of the other competitors have more or less adopted. Not so the character of their respective elevations, which are widely dissimilar; the first-mentioned being gloomy, tame, and unpicturesque in the extreme. It is therefore the more to be regretted that this design is the most completely illustrated by the geometrical drawings also; while Mr. Owen Jones has none at all worthy of note in the catalogue, and his unillustrated design is of some beautifully-studied and coloured portions at large. Mr. Owen Jones's design is not intrinsically very striking, except in boldness, but it is made so by the masterly skill of the artist, who, in the interior view (126), has overcome with consummate ability a very difficult task.

Mr. Sotheby's principal elevation differs from the others in its being more symmetrical, and planned on one continuous curve, whereas the others appear to follow more rigidly the precise outline of the ground. The style of the elevation is Italian—so far agreeing with the others by its site,—but there is a tinge of French about the works. 37 feet long, 25 feet wide, and 25 feet high, containing a booking office 88 feet long, 55 feet wide, and 55 feet high, with an office for ticket clerks 40 feet by 30 feet. "By placing the clerk's office central, first-class passengers have the great advantage of quietness, and being 'select,' an arrangement highly approved in effect in other stations, is adopted. The platforms are 25 feet wide, and the platforms and the floors, and a shoot carrying the goods to the second floor, based upon that of the Great Northern, containing a booking office 88 feet long, 55 feet wide, and 55 feet high, with an office for ticket clerks 40 feet by 30 feet."

On the second-class side are two waiting rooms communicating, and with direct access to the platform; also an easily accessible departure cloak room, with spacious entrance lobby communicating with platform and booking office. A conveniently placed cloak room is also provided on the arrival platform, with 'lost property' office adjoining.

The excursions or secondary booking office is 55 feet long, 25 feet wide, and 25 feet high, placed opposite the central platform; the ticket clerks are in offices taking tickets, and these are in a room of the space unencumbered (see drawing No. 1). A general waiting room, 30 feet by 25 feet, with ladies' waiting and retiring rooms, with the usual convenience, is attached.

The office 20 feet by 22 feet, approached from the end platform, is provided for the divisional superintendent, with easy distance from the stairs case to the company's offices.

An office 22 feet by 18 feet, is placed near the excursion booking-office for the G.E. agent; if requisite at any time, a staircase and another office of the same size might be constructed over, as there is ample height for the purpose.

Continued to the exit gateway, the exit staircase, and the arrival cloak room, is a convenient gentlemen's waiting room, with lavatory and dressing room attached, for the benefit of gentlemen arriving early from a long journey; similar accommodation is provided for ladies. W. C. and urinals are avoided in the gentlemen's room, as they are to be found close by. 

At the Great Northern Railway proves that a low lamp room is a great error, and the smell of oil a nuisance on the platform. I therefore propose a large square room, 82 feet by 30 feet, with a 10 feet passage way to the platform, placed in a central position, equally convenient for the lamping and unlamp ing of trains; this room would be supplied with zinc, with zinc shelves, brackets, sinks and counters, for every convenience of trimming, filling and repairing the lamps.

The principal 'outwards parcel office' is placed on the departure platform, similar to that at the Great Northern Railway and Great Western Railway, with this extra advantage, that a door at the end will enable large batches of parcels of private property, requiring special care, to be placed in a van on the outside rails before being attached to the train. 

A branch outward parcel office is placed at the street level, at the corner of the Euston and Old St. Pancras roads, adjoining the 'inwards parcel office.' By this means, I should obtain parcels from the rapid passing traffic and light carts, offering the same advantages as the various own receiving offices, and also helping to catch and divert parcels at present sent per Great Northern Railway or London and North Western Railway by means of offering more conveniences to those passing that way which these lines possess. 'Parcels received here would be forwarded to the inwards office above on platform, and conveyed to their proper vans.' 

The principal inwards parcel office would be on the platform level, at S.E. corner, where the parcels would pass through the books, then be sent to the sorting point, or hoisted to the delivery office. At the north end of the building parcels are placed at the street level, and also to the inwards parcel office at present sent per Great Northern Railway or London and North Western Railway by means of offering more conveniences to those passing that way which these lines possess. 'Parcels received here would be forwarded to the inwards office above on platform, and conveyed to their proper vans.'
On the second floor offices are provided for the company, subject to the last clause.

Entering the hall from the archway leads you at once to the bar and the grand staircase, and the groom of the chambers and hall-porter; opposite the bar is the entrance to the smoke and billiard rooms. Close by the foot of the staircase and the bar is the ascending room, and the lifts for luggage. Connected with the bar is the bar parlour, the manager's residence, a private sitting-room, and a large pantry. Over the kitchen is placed the coffee room, a handsome apartment, 55 feet by 35 feet, by 21 feet high, adjoining which is a serving room, (with lifts from the kitchen,) and the still room. Opening out from the coffee room and ready for general use for reading after breakfast. The remainder of this floor is devoted to dining rooms, a waiting's room, lavatory, W.C., and a bath room. The grand staircase and ascending room are taken up to the third floor, and the second ascends to once again to the third, and ends at the windows, and is known as the Managers' suite. A handsome office for gentlemen, and a famous hotel servants. Between the ground and first floors, along the frontage next a street, and towards the yard, I have provided for twelve beds, 9 rooms, 4 beds, approached from the hotel staircase. These rooms are not shown on plan. A second bar is provided at the landing of the first floor, a feature that has been recently added at the Charing Cross Hotel. Speaking tubes, small lifts, and a private stair communicate with the bar on the ground floor, and a small closet is added to the bar parlour. 1 lodge with an attendant, a library adjoining早餐, use for the use of families staying in the hotel but not having private sitting rooms, is placed over the principal coffee room, and has the serving room, with lifts from the kitchen and still room as before. Four private sitting rooms, 12 bed rooms, 1 dressing room, bath room and W.C., and housemaids' closets, are also provided on this floor in this section of the hotel.

I have proposed a feature in connection with the hotel and term "head-quarter" station that has not, I believe, before been adopted, but which I am sure will meet with the approval of all visitors. Just as the Grozvenor and Charing Cross hotels, and others interested in the development of similar matters.

There are a large number of gentlemen who run up to London for a few hours business, and have no offices where they can have a rest or make an appointment; they therefore go to some hotel, transact their business, and spend their money. I propose to make special provision for this valuable class of custom, for the benefit of both railway and hotel. I have proposed a certain section of the railway station and offices on the first floor, where gentlemen entering from the platform or the railway offices, can have their private room, and make their appointments where they can enjoy the luxury of a bath or washing after a long journey, finding every convenience lead to by; and have their guests in the news room overlooking the platform, join the table d'hote, and while away an hour till the train starts, in the billiard room or smoke room. The railway would appeal to them as offering a great advantage, the benefit of a complete hotel of great convenience and comfort, saving his time and money in running about London. A ladies' or private dining room, on the same plan, with dressing closets, is also provided, and a staircase leads to a mezzanine below, where accommodation may be found for visitors' servants, and for housemaids. The great advantage of the new arrangement is great convenience to the board of directors and superior officers, who thus have all the advantage of a first-class hotel at hand, and can take a friend in to dine, and wait their return trains, &c. The plan provided for is similar to the scheme for the Charing Cross Hotel. The promise of a more permanent and hoist leading to and from the platform are also continued up to the top of the house, and would be the ordinary means of exit from the hotel to the station, and entrance from the platform to the hotel.

The second floor provides for 5 sitting rooms, 37 bed rooms, 4 dressing rooms, 2 housemaids' rooms, 3 bath rooms, and 6 W.C. On this and other floors there are suites of rooms, comprising sitting room, bed room, and dressing room, with option of a second bed room. These rooms all open upon a small inner lobby with outer door and bell, with the number of the light in Charing Cross Hotel. The third floor provides for 5 sitting rooms, 45 bed rooms, 5 dressing rooms, 2 housemaids' rooms, 3 bath rooms, and 6 W.C. The fourth floor provides for 22 bed rooms, 1 dressing room, 1 bath room, 1 housemaids' room, and 3 W.C. 10 servants' bed rooms are provided in the pavilion roof. The total number of private lettable rooms is—22 sitting rooms; 152 bed rooms; 12 dressing rooms or small bed rooms. In addition to which there are 8 bath rooms, and 35 W.C. All these rooms are exclusive of the hotel accommodation.

The approximate estimate of the total cost is £245,000. We have ventured to transcribe thus largely, in order to show not merely the questions to be considered, and the difficulties to be contended with, but also the painstaking way in which they have, in this particular instance, been met—a labour recognised by the award of the third premium.

Mr. M'Gilligan's "New Town Hall" (132) is a bad adaptation of the New Town Halls of Northampton and Congleton, and not much can be said in favour of his two "District Churches" (234, 238). Mr. Petri's characteristic colour-sketches are as powerful and unmistakable as ever, and he has done good service to the Exhibition from year to year in sending so many of the productions of his facile brush. "The Great Mosque at Damascus," and "The Tomb of the Mamelukes at Cairo," are especially noticeable. Of sketches in pencil, also the result of foreign tours, there are not a few, including a liberal sprinkling from Mr. Digby Wyatt (163, 165). There are no few illustrations in this subject which realise the names of Mr. Nattress (152, 153, 181); and Mr. R. W. Edis (160, 162).

Mr. Truefitt exhibits but one drawing (158), containing a sheet of illustrations of the bank buildings now in course of erection, from his designs, at Manchester. It is needless to remark that these, like everything of the kind proceeding from the same source, will be of great value and satisfactory. In the case before us, as the chief feature is the treatment of an otherwise blank wall by a row of columns, and by a masonry squared and dressed to pattern, in a simple but effective manner. The font for Llandaff Cathedral (160), by Mr. J. P. Seddon, is a vigorous conception, and quite in keeping with the character of the venerable edifice for which it is destined. The attempt at novelty, unfortunately, not a very successful one, has been made by Mr. W. White in his new District Church, now being erected in Aberdeen Park, Belfast. The general outline is clumsy, and the dwarf central tower to such a building unmeaning; while the fanciful brick patterns on the interior surfaces are greatly exaggerated. In this building much has apparently been aimed at; and, as an almost necessary consequence, the result is less satisfactory than usual.

There are four drawings contributed to this exhibition by Mr. J. Drayton Wyatt: (80) being views of "the new church and the church promenade erected at the special request of Mr. W. Scott"; (115) "St. Andrew's College, Bradford, near Reading," showing the new "half-timbered" library, with studies and school-room, as proposed; to which is added a complete general ground plan; (131) an interior view of the "New Swimming Bath, now in progress of erection for Dril's Brighton Bath Company (Limited); and (239) an actual facsimile of the "Copley Church," near Halifax.

The Architectural Publishing Society, and the Class of Design belonging to the Architectural Association, are both represented as usual on the walls. The latter are this year particularly good, and some are highly finished as to deserve a better title than mere "sketches," proving the interest taken in the questions to be solved from time to time, and the degree of emulation evoked among the members who are wont to assemble.

Mr. Goldie and Mr. Pugin are exhibitors of sundry clever Gothic designs, each marked by the peculiarity of their respective authors. Mr. Pugin himself is of each work, and for the lucky office at the "Greshamian Church, John-street, Dublin" (231), by the latter, is, in particular, a noble conception, well worked out. In four highly finished outline drawings by Mr. A. M. Ridge (206, 209), we are presented with the "Design for a Hall of Science and Art," which received the Royal Academy gold medal, scholarship, and book, 1869,—an English Gothic composition, rather Venetianian in its details, which, beyond its careful delineation throughout, has not much to recommend it. Mr. Charles Barry reappears, in his "Dulwich College Estate Railway Bridges" (265); and Measur's and Barry, in their new "Westminster Chambers, Victoria-street," and the extensive buildings now being altered by them in the "Piazza Statuto, Turin.

The Exhibition will finally close on the 30th instant.

MECHANICS APPLIED TO ARCHITECTURE.

By R. O. Harris, M.R.I.B.A.

(With an Engraving).

The object of this paper is to invite attention to the leading facts of that art which guides and controls the entire order of employing the various materials we have to deal with in construction. The nature of those most commonly used, the different strains to which they are subject, and the forces producing them, in the parts of a building,—the force or weight applied, and the resistance, not only in framework but among the parts themselves,—the balance of forces, which leads to the consideration of its effect on framed beams, roofs, &c., or the balance of framework. The
consideration of arches and walls, with the thrusts upon them, will also have some attention.

**Forces and the Balance of Forces.**—Statics, or the science of balanced forces, may be simplified into weight and force, and a study of the conditions and the arrangements or weight to preserve a definite form, either by framing or the natural combination of the material within itself; and the investigation of the forces that are distributed so as to balance them, form the subject of this division.

The attraction towards the earth of a body, and the intensity with which it is attracted, is a result of gravity or weight acting in a line to the centre of the earth; not only does the entire mass act, but also the parts of which the weight consists, as in the case of a beam spanning an opening. Imagine a line in the centre of it being composed of an indefinite quantity of points or centres of attraction equally heavy, and acting in the same direction and in the line of gravity itself, parallel to each other; each of these centres is connected to each other by the natural cohesion of the material, and are collected at the centre, which becomes the centre of gravity of the line, and is always in the middle of its length. A rectangular beam (Fig. 1, plate 21) then, being considered as made up of an infinite number of points of gravity, has been reduced to a centre of gravity there. This system of finding the gravity of a beam by the action on its points applies equally to irregular shaped beams as well as regular, for example: if a beam be of this shape (Fig. 2), or has more to carry at one end than another, where will be found its centre of gravity, or the position a column should be placed under it to make the best use of the material. It is evident upon referring to the diagram that the masses on each side of the centre line A must be equal, therefore a point that has the parts all around it balanced must be its centre of gravity; the proof of this is simple, for if the mass be suspended longways from B, its weight will be found in the direction of B C; if suspended at D, in the direction of D E; and a line drawn through the centre thus found will divide the beam into two equal quantities; a glance at the diagram will show the correctness of this, and from whatever point the mass be suspended the vertical will cross the same centre. In triangular forms the centre is found by joining the opposite sides to the line of gravity, or the position a column should be placed under it to make the best use of the material. As in Fig. 3, the intersection will be the centre and position of the vertical line A, if the mass or beam were supported at each end. The centre of gravity of a regular cubed line is found by multiplying the chord of the segments by the radius, and dividing by the length of the arc, the fourth term giving the distance of the centre of gravity from the centre of the circle, for example, Fig. 4 takes an angle of 90° A, whose radius, AB, AC, form the sides of a square each equal to 1, therefore the chord C B is the diagonal, and equal to 1\(\sqrt{2}\), and the arc is equal to one fourth the circumference of the circle of 1\(\pi\) 72; the formula algebraically stand thus:

\[
\frac{CB \times AC}{CBD} = 0.9 \\
\frac{414 \times 1}{1572} = 0.9 
\]

giving the distance of the centre of gravity E \(\frac{1}{9}\) from the centre of the circle, showing clearly that a circular line is not equally balanced in quantity about the centre of gravity line, except when suspended from D. The application of these results will be further spoken of when referring to arches, curved ribs, &c. &c.

The whole of the assumed parts into which we have imagined the beam divided are rigidly connected together, and act with equal downward force in the middle or central line of gravity, and consequently equal to the load of the line. This collection of the separate forces into one at the centre is called the resultant of the load, and must be necessarily equal to it— and a measure or a result of the combined forces acting on the beam in a vertical downward direction and for distinction is called the vertical force. The two supports also, dormant as they appear to be in the example of the beam, are called the resisting or supporting forces, being always equal to the applied or vertical force. The power of resistance in a body is said to be somewhat analogous to gravity, and wonderfully accommodates itself to the force it has to resist, exerting so much force as is required only. The exact balance of these two forces maintain the body in state of forced rest or equilibrium, and are distributed throughout the beam in equal proportions.

We have considered as yet, forces acting vertically only, and irrespective of their intensity and direction. The laws of oblique forces, or forces acting at an angle with the horizon, differ essentially from the former, for their direction and intensity being given, we have to find a third that shall balance them, or one being of the same intensity and direction, or an amount of force each requires to balance the given one. Let two forces be inclined to a vertical, and represented by two lines, AB, AC, Fig. 5, whose position indicate the direction and whose length show the amount of force in units of a given weight. By drawing the lines CD, BD, parallel to the two given lines, a parabola will be described, and the same as the diagonal, &c. If a vessel of water be filled to the brim, and a flat board be floated on its surface, with three strings attached to it in any position by the pins 1, 2, 3, Fig. 6, now fasten three strings to them adjusted so as to pass over pulleys at the side, at A, B, C, and attach different weights at the end of each. The first thing to be observed is, that if the three lines are produced they will meet at a common centre at O, and if A be extended to represent inches in length, the weight at A, and DO at B; complete the parabola of which these are the sides, when it will be found that the two lines will intersect at F, and the diagonal FO will be equal to the third force.

These rules then refer to forces in a horizontal plane, and are difficult of application to building, where the neutralisation of gravity is the chief consideration. I have not been able to apply to my satisfaction the rules generally given for the parabola of forces, but I think the following a practical one, and easy of application, if not original. In the first place, the horizontal beam of a given weight, say 2 cwt., rests upon two supports with a force of one cwt. each, this we will call its horizontal thrust or pressure, AB, Fig. 7, while its vertical pressure will be represented by AC, which is the entire weight of the beam, or 2 cwt. It is evident that in passing through all the angles of the triangle half the weight of the beam is gradually increased from the other half and is therefore, in the vertical position of the beam in the vertical position upon the support A, and at every angle a portion of the weight acts with a force tending to turn the support A over at a loss of downward pressure on B. It will be seen on reference to the diagram, that when at an angle of 45° with the horizon, the two lines DF, EF, perpendicular to the vertical and horizontal lines AB, AC, are equal, but the pressures are not equal, for half the weight of the beam is still upon the support (A) but increased in the proportion of the sine of the angle DE, taking half the beam as a radius. The amount it requires to make the two cwt. being its pressure on the support A, for example, when 45° equals one cwt. or half the length of the beam, the sine of that angle is the line DE, and equals 0.707, therefore the pressure on the support (A) equals 1707, and on B if it were raised to it would be the difference or 293, and the outward thrust on (A) 707. The application of this rule to a pair of rafters will be in precisely the same manner, of course considering the two pressures that meet at the junction of the rafters as vertical pressures, and equal to each other. Should each side not be the same angle, the method of proceeding would be still the same, but the different downward pressures at the apex require to be neutralised which may be done by directing the pressure there at another angle, which will be treated of more fully in its place on the balance of framework.

Another very important force, of which we are continually seeing the effects, claims a large share of our attention, that is the principles of leverage or the theory of couples. I regret not being able of this book and will illustrate myself more particularly to the application of practical rules to construction, giving just so much theory only as is required to show the means by which the conclusions are arrived at, and to render the subject traceable to more detailed works. Two equal forces acting in opposite directions, but not in the same line of action are called a couple. The two forces in a beam, for instance, the vertical and supporting pressures as before described acting in the direction of the arrows AB, Fig. 1, while the distance between them is called the arm or leverage of the couple. You will readily perceive that if the beam were extended along to D, the

* Mosley's Mechanics.*
force at $D_1$ would tend to turn it on the base or fulcrum $C$, and the distance $BC$, multiplied by the force applied, is called the moment of that force, hence a beam fixed at the ends is doubly as strong as one merely supported, because the leverage is equally balanced. Suppose a man to stand on any other material, $fig. 5$, required to be moved, say on a centre at $(a)$, and require forces to move it 40 lb. each applied in the direction of the arrows $b$, the leverage will be equal; but if, instead of applying the force at $b$, it is exerted at $c$, it will require 70 lb. to produce the same effect as $b$, does, and a corresponding alteration in the upper force $c$, to produce only a force of 10 lb. Taking then each of the divisions as representing 10 lb., multiply the weight on one side by the divisions on the other; the result is the moments of the forces.

Before applying the foregoing rules to construction, I have to ask your attention to a few remarks on the strength of materials. There is no part of my subject of greater importance than investigations connected with the strength of materials; the resistance to forces varying applied is first ascertained by practical experiment, and upon it depends the most satisfactory demonstration of the rules deduced therefrom—and what are called the laws of the forces or modulus of strength to resist forces in a given direction. Whatever be the position of the force or load with respect to the material to be acted upon, the resistance or tendency it has to recover its original state is called its elasticity. When the force applied is not so great as the direct elasticity of the material, the body is said to be elastic (to a certain degree) if the load is increased beyond the breaking point, mention that the laws of elasticity applied to a sphere equally apply to a beam, for if it is compressed transversely it lengthens longitudinally—and vice versa. The load applied to cause fracture is called the breaking load; and the load that may be applied with safety, without injury to the material, is called the proof load.

The different ways a material may be injured or broken we may reduce to two: that where the force is applied longitudinally, and transversely. By the first we may have tension—tenacity or resistance to tearing—and compression or crushing by a direct thrust. The force applied transversely produces three principal kinds of fractures: 1st, distortion or shearing (that is the sliding of one part on another); 2nd, twisting or wrenching; and 3rd, bending or breaking across. The following table* will give the moduli of strength or the force under which a given material begins to yield or fracture. The experiments being made or reduced to the application of the force in poult to resist forces in $a$, in the case of breaking across they are reduced to bars one inch square and one foot between the supports.

<table>
<thead>
<tr>
<th>Extension Tension, or Tenacity,</th>
<th>Compress or Crushing Angusways</th>
<th>Cross-breaking</th>
<th>Shearing</th>
<th>Modulus of Elasticity, Stretching</th>
<th>Modulus of Elasticity, transversal Distortion.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Fir</td>
<td>18,000</td>
<td>5700</td>
<td>472</td>
<td>650</td>
<td>1,800,000</td>
</tr>
<tr>
<td>Oak</td>
<td>15,000</td>
<td>10,000</td>
<td>700</td>
<td>2300</td>
<td>1,400,000</td>
</tr>
<tr>
<td>Cast Iron</td>
<td>16,000</td>
<td>112,000</td>
<td>2222</td>
<td>27,700</td>
<td>17,000,000</td>
</tr>
<tr>
<td>Wrought Iron</td>
<td>60,000</td>
<td>38,000</td>
<td>2333</td>
<td>50,000</td>
<td>29,000,000</td>
</tr>
<tr>
<td>Sandstone</td>
<td></td>
<td>4400</td>
<td>88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slate</td>
<td>10,000</td>
<td></td>
<td>280</td>
<td>15,000,000</td>
<td></td>
</tr>
<tr>
<td>Brick</td>
<td>290</td>
<td></td>
<td>900</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limestone</td>
<td>400</td>
<td></td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortar</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are three principal forces which are generally comprehended under the word stress:—1st, thrust or compression, when each pushes the other towards the centre; 2nd, tension or pull, when each draws the other; and 3rd, shear, when each draws the other on itself.

The strength of timber depends on the adhesion of the two tissues, the fibrous and cellular, arranged in alternate rings. The fir woods are those mostly that contain turpentine, the fibres are straight, and their resistance to tension is considerable, being nearly that of oak; but the adhesion of the fibres to each other is very small, their consequent resisting power to shearing is but 650 lb.; whereas in oak it is 2300 lb.: a fact to be borne in mind when the force at the end of a tie beam is great. The tenacity of the fibres to each other of oak, and its durability, give it an advantage over fir, particularly for columns; but its proportion for bearing a transverse load is not sufficient to compensate for its extra cost over fir.

The strength of cast-iron is remarkable, as having its resistance to tension so small (16,500 lb.) as compared to crushing (40,000 lb.). Also the greater tenacity of the skin or exterior of the beam than the interior. Wrought-iron, like other fibrous substances, loses more tenacity in consequence of tension (60,000 lb.) is greater than to crushing (38,000 lb.).

On Beams and Girders.—In a former paragraph has been described the weight or load of a beam, and its resisting pressures. We have now to deal with the action of a transverse load upon it. The gross load is transmitted by the beam to the piers, in the proportion of its distance from the walls; the force of gravity acts upon them and is distributed among the piers causing a compressive stress in the upper part and a tensile stress in the lower, acting against each other, and at the division of these two actions is a neutral plane or neutral axis, as it is generally called, which will be situated in the depth of the beam proportionate to the tensile and compressive strength of the material; or in other words, reduced from the formula, the sum of the tensile and compressive moduli of strength is to each of them as the entire depth to each of the depths. For example, a beam of fir, 10 ft. long, 4 inches $\times$ 4 inches, calling $T$ the tensile force of the material, and $C$ compression, $D$ tension depth, and $De$ compression depth; then,

$$ (T + C) : C : : D : De \cdot \frac{18,700}{5,700} : \frac{13,000}{4} : 2,219 : 2,775 $$

and the neutral axis of the beam will be nearly $\frac{2}{3}$ in. from the bottom and $\frac{1}{3}$ in. from the top; this may be taken as a fixed rule for that the neutral axis will lie at the difference of the depth of the beam (50 lb. = 755 lb.), will be equal to 755 lb., the strain acting upon the fibres of the material in the centre; the breaking load of the beam is 2,500 lb.; therefore, the working load should not be more than 643 lb. or $\frac{7}{4}$. It must be noted that this is the central strain, and that it gradually diminishes towards the supports, where it disappears.

It is clear then that a beam will be equally strong for a central load if its depth be regularly diminished from the centre to the ends, as diagram fig. 8. If the load upon the beam should not be in the centre, the entire load will be distributed on the two walls, in the proportion to the distance from them, inversely; for instance, 100 lb. placed at one fourth the span will give 75 lb. pressure to its nearest wall, and 25 lb. to the opposite one. The strain at the various points will be given by multiplying the proportion of the weight transmitted, by the distance of the weight from the wall, and dividing by the depth of the beam, thus: $\frac{75 \times 30}{4} = 562$, and $90 \times 25 = 562$ lb. the strain on the beam at the point with the weight there. With regard to beams with the load uniformly distributed (which we have generally to consider in practice) it is a law in mechanics that an equally distributed load on a lever is equal to the same load collected midway upon the length of the lever at $A$, fig. 10; therefore, the strain induced on a beam equally loaded with the same weight is only half of that concen-
treated at the centre, and the value of the previous formula becomes doubled, thus, \( \frac{WL}{8D} \) equals the strain on the centre; this also diminishes towards the ends, but not in the same regular proportion as the central loaded one, but in exact proportion to the verticals from an ordinate of a parabola, which gives the shape of the top, when the material is so distributed to counteract the strains induced. We have the strain in the centre given in the expression \( \frac{WL}{8D} = 1 \), (Fig. 11), the ratio at the other points is found by dividing the product of the two lengths \( l_1, l_2 \), into which we divide the beam by the square of half the length, and this expression will give the height of any vertical required, \( \frac{l_1^2}{l_2^4} = 8 \), or the strain at that part; thus, dividing a 10 ft. beam into 10 equal lengths, and start with the strain in the centre as 1; the following give the height of each of the verticals:

\[
\begin{align*}
24 &= 86, \\
21 &= 84, \\
16 &= 84, \\
9 &= 36
\end{align*}
\]

thus forming a parabolic curve at the top. Not only showing, but perfectly demonstrating, this truly scientific and useful law.

The principles of leverage are closely connected with the strength of beams. A plain beam fixed in the wall in the position of a cantilever breaks with \( x \) lb. applied at the ends; and \( 2x \) lb. with the weight equally distributed. In a beam twice the length of the cantilever, and twice the load, \( 2x \) would break it applied in the centre, and \( 4x \) if it were distributed, and \( 8x \) if the ends were rigidly fixed; this is sometimes given as \( 6x \), making allowances for the slight increase of rigidity from rigidly fixing.

So far then as we have gone it will be seen that the few rules given are really self-evident, and not so perplexing as some practical men would lead us to infer when fully acquainted with the causes that produce the different results in experiments on the same material. So entirely are we dependent on this weight and accuracy of the experiment, and as the state of the material at the time, that it becomes a matter of the greatest consideration whose experiments we adopt. They certainly should be those whose means of application and accurate skill have been the test of many years. Telford, the engineer, in his memorandum book collected many useful data on the strength of materials, particularly oak and fir; Fairbairn and Hodgkinson being the chief authorities on ironwork. The table given above is made up from Professor Rankine's work on Applied Mechanics, and is well considered. The method of arriving at these measures or moduli of strength, is to find the breaking weight in pounds of a bar one inch square and one foot between the supports for cross-breaking, giving the result in foot-pounds, and for crushing and dragging in pounds on the square inch or inch-pounds, as strains are generally calculated. Oak and fir being the principal timber used in building, we will attend to these now, iron being deferred until speaking of iron structures, bearing in mind that the same general rules apply to all materials. Telford gives the cross-breaking weight for oak as ranging from 160 lb. to 584 lb., and later Rankine gives 700 lb. (see table). So if we take 600 lb. for oak and 450 lb. for fir as constants of strength, we have a fair average on the safe side of the breaking weight. The causes of the difference of the constants varying first, are condition or quality, which is as specific gravity when seasoned or free from sap, next that the heart of wood is stronger than the outside, and lastly, that even the outside of a tree differs in strength, that portion exposed to the sun having its fibres and tissues stronger.

The number of cases of cross-breaking will be found in each section that will break or fracture with a known weight a bar one foot long. We have now to consider the effect on a longer bar and of larger sectional area. Telford gives a bar of oak 8 feet long and 5 inches square as breaking with 9757 lb., against which theory sets 12 lb. to the inch, 9757 lb. for 16 feet, 4350 lb., against theory 4461 lb., and for 24 feet long 2162 lb., against theory 2400 lb.; which proves sufficiently near for all practical purposes that the strength of a square or rectangular beam to resist cross-breaking is as the breadth of the square by the depth inversely as its length. Thus a beam twice the width of another, all other circumstances being equal, is twice its strength, whereas twice the depth gives four times the strength, and twice the length equals nearly half the strength. Taking the 16 feet beam referred to, and calling \( W \) the breaking weight equal to 651 lb. to one foot long one inch square, \( B \) the breadth in inches, \( D \) the depth, and \( L \) the length in feet, then

\[
\frac{WBD^2}{L} = \frac{(LBD)^2}{8}
\]

or, in figures, an oak beam 16 feet by 5 inches by 5 inches, will have 4461 for the breaking weight in foot-pounds, one fourth of which only should be used in practice.

\[
651 \times 5 \times 25 = 5086 - (5 \times 5 \times 25) = 4461 \text{ lb.}
\]

Timber beams to carry heavy loads are strengthened by iron or trussing, so as to increase their rigidity, also frequently by cutting down, reversing, and bolting together, which from the point of view of beauty advances the thing next to useless, if it does not tend to weaken. Another method is to connect it with a more rigid material, as oak or iron. In the case of fir, or oak and iron, the calculation will be simple enough, merely by finding the sum of the strength of the two materials. In the case of trussing, whether above, below, or within the beam, the actual strength of the wood is increased by the separate strength of an iron rod truss, which on the top will be in tension and when at the bottom in compression, the strength of which will be hereafter described under trussing; the actual tie bar being replaced by the material of the beam in the place of a king truss the beam can only be equally strong throughout for a central load, therefore a queen truss is preferable where the load is distributed.

The balance of framework may be commenced with two inclined timbers, as the rafters of a common roof (strictly it requires not less than three timbers to form a frame, but the thrust of these are so closely connected with framework that I have introduced them here). The permanent or distributed weight on a roof is generally calculated at 40 lb. to the superficial foot and taken from centre to centre of trusses or rafters as the case may require. The two rafters are taken at 10 feet long, and at an angle with the horizon of 30 degrees. The weight of a rafter beam in the roof is usually required, which must be calculated for the proof load, or one fourth the breaking load, (1 may add that this method of proceeding applies to all beams on two supports when the weight to be carried is known) this makes the load to be calculated 1600 lb., and an inch bar of fir one foot long breaks with 450 lb. applied in the middle, therefore the following formula (as before gives)

\[
\frac{450 \times 5 \times 8^2}{L} \text{ equals the breaking weight, or 41 lb. for each bar 10 feet long and one inch square, doubling this for 2 inches the breadth of the rafter gives 82 lb., which multiplied by 2 inches deep or 4 equals 328 lb., by 3 inches deep or 9 equals 738 lb., by 4 inches deep or 16 equals 1312 lb., by 5 inches deep or 25 equals 2054 lb., a little over what is required; therefore 6 by 6 will be sufficiently strong for the rafters of a roof having a 10 feet bearing. Tredgold gives common rafters with a 12 feet bearing, 6 inches by 2 inches, which considering the heavy scantling generally given by him, the working out shows is a very fair approximation to the actual strength required. Now as to the actual weight upon the walls, the horizontal and the vertical thrusts. First, as to the direct weight, imagine the rafter divided into four equal parts, each representing 100 lb. Dividing it into pound divisions from the centre \( b \), let fall the perpendicular \( ab \), Fig. 12, which will be the sine of the angle, and equal in length to 3 if supposing the distance \( c \) to be the radius, and equal to 1, from \( b \) as a centre transfer the length \( c \) to \( d \), which will make it equal to 1 or 2; the length of the rafter, therefore equal to 300 lb., which is the proportion of the weight upon the wall acting in the direction \( cd \), the remaining 100 lb. being the vertical weight or pressure from the apex or upon another support placed there. The amount of thrust on the lower rafters will have upon the wall \( c \) will depend on the angle of the slope and the consequent leverage. You will observe, as shown on the diagram (Fig. 13), that the greatest force required to hold the horizontal beam in its position, by a weight at \( A \), is greater than at any other angle; therefore the greatest tension and compression is exerted as the pitch of the roof becomes flat. The line \( AB \) represents half the total weight on any roof, \( DC \) will represent the tensile

\[
\frac{WBD^2}{L} = \frac{(LBD)^2}{8}
\]
strain, and BC the compressive strain. This is known as a diagram of force, and, as you will observe, dependent on the parallelogram of forces. Referring to our former diagram, we require the thrust on the wall—form a diagram of forces, and make \( e_f \) equal to 600 lb, the total weight; then \( e_A \) will represent compression, and \( e_B \) the tension. Having thus determined the stress, the horizontal thrust being equal to it. To confine the feet of the rafters, and convert the outward thrust into a vertical pressure, the tie or tension beam is connected to them by a notched joint, the force is then exerted to shear off the end piece, unless secured with straps; the resistance to the force is by the adhesion of the fibres of the wood to each other, the pressure to the bearing being 650 lb to the square inch, one-tenth of which only should be trusted, as a force suddenly applied acts powerfully in the shearing of the wood.

In the case of a king-post truss, the weight being ascertained, the former rules for finding the compressive and tensional strains on inclined timber are just the same—as the span is wider, the ties and principal rafters require supporting by struts and rods. When the truss is merely a triangular frame of three bars, the load is considered as concentrated at the apex, but when braced or strutted, so as to portion the weight equally at the junction of the braces with the rafters, this causes the compressive and tensional strains in the tie and rafters to become greater as they near the supports, and decrease to the centre.

In an ordinary king-post roof, with a span of 30 ft. and a rise of 8 ft.—let the lines in the diagram, fig. 14, represent the centre lines of the timbers, with a total weight on the ridge of 20 cwt., to be divided on four bays of the rafters—giving 5 cwt. to each.

To find the strains on the timbers, as far as possible, proceed as follows: first, the tie beam, determines the greatest, which will be at \( a \), and let the letters denote respectively—the rafter, half tie, and rise, \( L \) being the gross load—then tension or \( \frac{L}{2R} \) at \( a \); and

\[
\frac{\text{less at } b; \text{ or calling } N \text{ the number of bays } \frac{L}{N} \text{ deducted from the first gives the strain on that portion, and so on for any more bays required. The compression is found in precisely the same manner: } C = \frac{L}{2R} \text{ for the first, and } C = \frac{L}{2R} \text{ for the strain on the tension rod.}}
\]

To apply these rules to a roof of 60 ft. span, fig. 15, without intermediate supports—first find the angle with the horizon the roof is to be, say a rise of 20 ft., by which you find the length of the rafter—twice this, by the distance between the braces, say 9 ft. by 40 lb. per foot, or nearly 12 tons, without the weight of the truss. Suppose the span 30 ft. long, have to be supported in not less than four bays, giving them the section—how to obtain the scantling of them, as well as the purins, has been described—the struts on the trusses then enable us to find their scantling.

The tensive strain on the tie beam is equal to load \( X \) half the span divided by twice the height \( \frac{12 \times 30}{40} = 9 \) tons for the roof alone.

pull or tension on the tie beam, and the strength of \( f \) in this direction is very great, requiring about 5 tons to tear a.sa 1 bar 1 inch square: therefore a bar having 12 square inches in it would be amply strong to resist the tension—it has about a 15 feet bearing, probably a heavy ceiling, loft, or floor to carry, allowing then 1 cwt. foot super for this, we have 30 tons to carry, multiplied by 5 for the safety load = 12 tons.

The usual calculation for floors to carry a distributed load for general purposes is 1 cwt. per foot superficial; then, taking the floor joists as 15 inches from center to center, and the bearings 10 feet, we have 12 cwt. on each joist calculated in the usual way, as before given, we then have a gross weight of 130 tons to calculate for in struts. Taking for one case, the floor is in equilibrium, and all the strains neutral and maintained into vertical pressure—taking 8 inches for the thickness of the timber—what will the depth be? 15 ft. is the greatest distance between supports, represented by \( L \) or length in feet, \( B \) equals the breadth or \( 8 \) in, and \( 147 \) represents nearly \( 12 \) cwt., nearly the constant or strength of \( f \)—then \( D \) equals \( \frac{L}{B} \times \frac{147\times D}{8} \), or \( \frac{8}{147} = 11 \times 0.95 \), or 11 for the depth. Let us now suppose

the central tension rod removed: \( V \times 1.47 = 22\times0.5 \), which would require secondary trusting or otherwise strengthening, so as to reduce the depth, or else increase the width.

For the principal rafter—let the former letters apply as before, and change the constant to decimal 0.96

\[
\frac{B^3}{8} \times 0.96 = D, S
\]

giving the entire span—in figures it stands

\[
51x180 \times 0.96 = 9114
\]

or \( \frac{8}{147} = 11 \times 0.95 \), or 11 for the depth. Let us now suppose

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the central tension rod removed: \( V \times 1.47 = 22\times0.5 \), which would require secondary trusting or otherwise strengthening, so as to reduce the depth, or else increase the width.
equal to one fourth the gross weight, is equal to half the above from a b (because the vertical only represents half the diagonal of the parallelogram). The consequent strains at the springing of the roof are represented by the triangle a d e, supposing a d to equal three-eighths of the gross weight of the roof, or the force tending to throw over the wall at each side e of a d.

Under these circumstances, the forces are a c, a c parallel to e c, and a d parallel to a d, then will the triangle a c e represent the forces at the springing of the roof; a e representing the inclined strains, e b the horizontal strains, and a b three-eighths of the gross weight. The triangle a d e giving the strains on the upper part of the truss, you will observe the assistance given to the inclined thrust by the hammer-beam bracing, converting it into a vertical one, and relieving the horizontal strain. The curved braces certainly tend to strengthen the truss, but depend upon the cohesion of the material, bolts, &c.; therefore not generally considered in relation to the direct strains, but properly secured in at the joints, and supposed to be straight; the strain in that direction will be given by the line e c in the diagram of forces.

**Arches and Wells.**—If two cubes of stone (Fig. 21) be so placed as to touch another block half the size, as in the sketch, the block b will be sustained by them, by reason of the inequality of the granular surface or friction, with a force equal to its weight, its consequent tendency is to push out the outside or horizontal direction equal to forces: if a succession of these stones (Fig. 22) when placed together and supported at the ends, by an immovable abutment, we have an example of the straight-arch or plate bands, if the span of the arch at top be divided into four equal parts, and we join a b d e a, and draw the direction of the line a b, it then will be equal to the horizontal outward thrust. The resistance of a pier is of course dependent on the direction of the forces applied. Let the arrow in sketch (Fig. 23) represent that direction, for simplicity say an angle of 45°, then supposing the resultant of the horizontal and vertical forces to be represented by a line l, then b will be equal to each other, then the line of resistance in pier or wall will be an hyperbolic curve represented in the dotted line in the direction of the arrow. Should the direction of the force not be at an angle of 45°, let the dotted portion above the pier represent the proportion of the vertical (d) to the horizontal (e) of the force applied, and the pier shall be off a horizontal pier equal to the horizontal force d e; then will be the centre of the hyperbola, and the vertical g will be its asymptote. The property of this curve being that it is always approaching but never touches its asymptote; therefore, while this line is within the pier or wall, the line of resistance is, and no force in the direction and quantity given can overthrow the mass. Supposing that the horizontal thrust to give the vertical outside the wall (as in Fig. 24) it must be either reduced in height, or a buttress must be added to bring the line of resistance within the wall. Taking a b as before to represent the horizontal thrust, let fall the vertical e f, and draw the hyperbolic line d g, which will indicate the height of the given wall to resist that pressure, or the amount of buttress required to give the pier its requisite strength. I am sorry time will not allow me to pursue this subject further just now, as I have a little to say on arches.

The description of arch stones is considered horizontal up to an angle of 30° from its springing, because a mass of stone will stand upon an inclined plane at that angle without moving down. Taking then a semicircular arch, with the stones containing 20° each. Stone 1, next the springing sustains itself on a horizontal bed. Stone 2 is also considered the same, as it is springing at an angle of 30°. The bed also resists a horizontal thrust equal to half their weight. Stone 3, being on a bed at 45°, requires a horizontal force to maintain it in equilibrium, that will be found in the equation, that the force is to the weight as the line of 10° is to its cosine:

\[ \frac{W}{T} = \sin 10° : \cos 10° \]

and so on for the remainder. This will enable you to find the horizontal thrust of any arch, which if the piers are not calculated to resist, throws them out at the springing, and the arch in at the crown, causing it also to open at the haunches.

Those wishing to pursue the subject of Arches, Piers, &c. will find them ably treated by Professor Moseley in Vol. 9 of "Principles of Engineering," and Professor Rankine's "Applied Mechanics," Tredgold, and Telford's memorandum book,—works to which I gratefully acknowledge my obligations in the preparation of the foregoing notes.

**ROYAL INSTITUTE OF BRITISH ARCHITECTS.**

At the ordinary general meeting held on the 30th of April last, A. J. B. Beraford Hope, M.P., President, in the chair, the Royal gold medal for the year 1865 was presented to M. Digby Wyatt, F.S.A., of Tavistock-place, Tavistock-square, Fellow, and the other medals and prizes as follows:—To Mr. Charles Henman, jun., of Bedford-place, Croydon, the Institute's silver guineas; to Mr. Arthur Baker, of Inkerman-terrace, Kensington, the institute medal; To Mr. M. H. Renault Margin, of Nottingham-street, Regent's-park, the late Sir Francis E. Scott's prize of ten guineas; to Mr. J. S. Nightingale, of Parliament-street, the students' prize in arts.

The following paper was read at the meeting, by Prof. Robert Kerr, Fellow: "Remarks on the evidence of architects on the obstruction of Ancient Lights, and the practice of proof by measurement, with reference to recent cases in the courts of equity." The discussion on Mr. Kerr's paper, to be commenced by Prof. T. L. Donaldson, past president, was adjourned till Monday, the 29th of May.

At the annual general meeting, held on the 7th of May, 1866, A. J. B. Beraford Hope, M.P., President, in the chair, the following office bearers were elected for the ensuing twelve months:—As President, A. J. B. Beresford Hope, M.P., Honorary Fellow; Vice Presidents, T. Harter Lewis, D. Brandon, J. Ferguson; Honorary Secretaries, John P. Seddon, Chas. Forster Hayward; Honorary Secretary for foreign correspondence, C. C. Nelson; Treasurer, Sir W. E. Farquhar, bart.; Honorary Solicitor, Frederick Ouvry; Ordinary members of Council, A. Ashpheit, E. M. Barry, A.R.A., F. P. Cockrell, J. Gibson, E. Lamb, E. Naps, B. P. Papworth, J. M. Smart, G. W. Wetherby, J. Whitchord, W. White, M. Digby Wyatt; country members, M. E. Hadfield, Sheffield, R. M. Phipson, Norwich. Auditors, E. H. Martin, Fellow, T. H. Waton, Associate. As examiners under section 33 of the Metropolitan Building Act, in the elections of the three Vice Presidents, and Mr. C. C. Nelson, A. Ashpheit, C. Fewster, jun., J. Gibson, J. Jennings, H. Jones, E. Nash, H. Oliver, J. W. Papworth, J. Spencer-Bell, J. Whitchord, G. B. Williams, S. Weed, and the two Honorary Secretaries. Votes of thanks were passed for the services of the President, Vice Presidents, Honorary Secretaries, Ordinary members of Council, and the other office bearers during the past year.

At the ordinary general meeting held on the 21st ult., David Brandon, F.S.A., Vice President, in the chair, a very interesting paper on "Battle Abbey, and its conventual remains," was read by the Rev. Mackenzie E. C. Walcott, M.A., F.S.A. At the same meeting the chairman announced that the following letter had been received in regard to the resignation of Mr. F. J. Tugwell as President to Sir George Grey, H.M. Secretary of State for the Home Department, at the request of the Council under the advice of their Honorary Solicitor, Mr. Frederick Ouvry.

Whitehall, 15th May, 1866.

Sir,—I have the honour to submit to the Queen your request that the Institute of British Architects may be permitted to assume the title of Royal; and I have the honour to inform you that His Majesty has been graciously pleased to accede to your request, and to command that the Institute shall henceforth be styled the "Royal Institute of British Architects." I have the honour to be, Sir,

Your obedient Servant,

A. Beresford Hope, Esq., M.P. (signed) G. GREY.

It was explained that this title of Royal, though assumed by the Institute, was not granted by the original Charter, and the object of the application was to remove any doubt or difficulty on the subject.
ROADS AND RAILWAYS IN INDIA.

By Sir William Denison, K.C.B., Colonel, Royal Engineers.

(Continued from page 138.)

MAINTENANCE.

The next matter for consideration will be the cost of the maintenance of way, that is, the annual outlay required to maintain the road in a state of thorough repair.

This must, of course, so far as the macadamized road is concerned, depend upon the amount of traffic, while the quality of the materials employed will have some action upon the annual charge. A fair approximation of this charge, however, may be arrived at by a reference to the amount commonly allowed for maintenance upon the great trunk lines of road in this Presidency, and Rs. 300, or £30 per mile, would be considered sufficient for a road upon which the standard amount of traffic is conveyed. The cost of repairs upon a road over which 1972 vehicles pass per day has, in an average of five years, amounted to £119 14s. 9d. In order to be on the safe side therefore, I propose to allow £55 per mile for the maintenance of the macadamized road of line of road in thorough repair.

On the railway for animal power an allowance must be made for the wear and tear of rails and sleepers. The general wear of the road itself will be very much less in course of time than that of the macadamized road, for the iron rail takes almost the action of the wheel; if, then, the rails and sleepers are renewed in twenty years, one-twentieth of the whole cost may be provided as an annual charge; and as this is £1700, one-twentieth of that sum will be sufficient for the replacement of the rails and sleepers, that will be sufficient to cover the cost of other repairs, so that 85 + 15 = £100 will cover the cost of the maintenance of the railway for animal power.

The maintenance of way upon the railway for steam power must necessarily include an allowance for the renewal of rails, chairs, etc., and by taking the duration of these at twenty years, as in the railway for animal power, an advantage will be given to the locomotive line; as the action of the heavy engine, going at the rate of 20 to 30 miles per hour, must wear away the rail much more rapidly than the light and slow action of the animal power. Assuming then 5 per cent. to be the annual deterioration of the rail and sleepers, the charge for maintaining the Madras line, to be £9000 per mile, the annual charge for renewal of rails and chairs will be £150.

The other items under the head of maintenance are grouped together in the returns, and the cost may be put on an average at about £100 per annum mile, while the charge for superintendence may be put at £5. The cost of maintenance of way on the steam power line will therefore be as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>£  s. d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewal of rails and sleepers</td>
<td>150 0 0</td>
</tr>
<tr>
<td>Labour, ballast, etc.</td>
<td>100 0 0</td>
</tr>
<tr>
<td>Superintendence</td>
<td>5 0 0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>£255 0 0</strong></td>
</tr>
</tbody>
</table>

The annual charge upon the three descriptions of road, under the head of interest of capital and maintenance of way, will be shown in the accompanying table:

<table>
<thead>
<tr>
<th>Class of Road</th>
<th>Interest</th>
<th>Maintenance</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macadamized road</td>
<td>37 10 0</td>
<td>55 0 0</td>
<td>92 10 0</td>
</tr>
<tr>
<td>Railroad, Animal power</td>
<td>131 7 0</td>
<td>100 0 0</td>
<td>231 7 0</td>
</tr>
<tr>
<td>Railroad, Steam power</td>
<td>600 0 0</td>
<td>355 0 0</td>
<td>955 0 0</td>
</tr>
</tbody>
</table>

| **Total £292 10 0** |

**Traction.**

Having thus arrived at the cost of constructing the different lines of road, as well as that of maintaining them in a good state of repair; all that remains to be done is to determine the actual cost of traction upon each. To do this, however, would involve the solution of a variety of very complicated questions. It will be far more simple therefore to show, for the ordinary roads and for the existing railroad, the actual charge for the conveyance of passengers and goods. In the case of the railroad, the returns show the actual charge for locomotive power under several different heads; while on the macadamized road the contract price per passenger or per ton of goods includes not only the charge for power, but a variety of other items to which I shall allude hereafter.

With reference to the railway for animal power, I propose to submit a detailed estimate, on a liberal scale, of the cost of working it, as in this country I cannot obtain any direct information to guide me.

The cost of conveying goods upon the ordinary roads has been shown to be 3d. per ton per mile. This sum includes the interest of the first cost of the road, the maintenance in repair of the vehicle; the maintenance of the cattle, and the hire of the persons employed to drive them; it will also include a premium of insurance upon the carriages and cattle, so that they may be replaced in case of destruction or death by accident or disease. It also includes, or should include, some premia in consideration of the risk incurred by the owner who is responsible for the goods under his charge. In addition to all these, it must include such a fair amount of profit as the contractor has a right to expect, besides the simple interest on his capital.

The charge of conveying first-class passengers may be put at 6d. per mile. This is arrived at by taking the cost of conveyance, by the Transit Company, from Tripatoro to Bangalore, a distance of 80 miles; the transit is capable of accommodating two persons inside, and a servant on the box by the driver. Each person may take 40 lb. of baggage, and the total charge by the company is Rs. 40, or £8; that is £1.60 per mile, or 6d. per each passenger.

A class of passengers analogous to the third-class on the railway is conveyed to and from places in the vicinity of Madras, at a reasonably rapid rate, in vehicles drawn by bullocks or ponies; each of these vehicles is capable of containing four people, and the rate of charge varies from 3d. to 3d. per mile for the whole vehicle. Taking the last sum, that of 3d. per mile for each passenger would be 3d.; but it would be safer to estimate the average cost at 1d. per mile per passenger, and this may be taken as a fair charge for such work in any part of the Presidency, as the Madras prices are probably in excess of those of the country districts. The cost then of conveying 3220 first-class and 152,000 second-class passengers, and 32,000 tons of goods, will be as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>£  s. d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,220 at 6d.</td>
<td>80 10 0</td>
</tr>
<tr>
<td>152,000 at 1d.</td>
<td>152 0 0</td>
</tr>
<tr>
<td>32,000 at 3d.</td>
<td>320 0 0</td>
</tr>
<tr>
<td><strong>Total £1313 18 0</strong></td>
<td></td>
</tr>
</tbody>
</table>

The returns for the North West Railway, for the same amount of traffic, exhibit the expenditure under the various heads of classification, as shown in the following table:

<table>
<thead>
<tr>
<th>Item</th>
<th>£  s. d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotive department</td>
<td>1906 5 24</td>
</tr>
<tr>
<td>Fuel</td>
<td>3054 12 0</td>
</tr>
<tr>
<td>Coaching</td>
<td>1259 1 0</td>
</tr>
<tr>
<td>Tickets</td>
<td>12 2 4</td>
</tr>
<tr>
<td>Repair of vehicles</td>
<td>113 0 0</td>
</tr>
<tr>
<td>Electric telegraph</td>
<td>11 9 0</td>
</tr>
<tr>
<td>General charges</td>
<td>117 6 0</td>
</tr>
<tr>
<td><strong>Total £4775 13 6</strong></td>
<td></td>
</tr>
</tbody>
</table>

This sum, divided by 41:25, the length of the line, will give £117 7s. 4d. as the cost of conveying the whole of this traffic over one mile of railway. No attempt is made to distinguish the actual cost of conveying the different classes of passengers or goods; in fact any attempt of the kind would merely be a matter of guess work. The above may be taken as facts, which do not involve any calculation.

I have now, however, to form an estimate of the cost of conveying the same quantity of goods, and the same number of passengers, along a railway by means of animal power.

The number of first-class passengers has been put at 3220, or roughly, 10 per day, or 3 each way. To convey these, one first-class carriage would be required, which would travel at the rate of 10 miles per hour. It would be more economical to procure well under the estimated price, probably for Rs. 500 each. But the supply is very limited, and in the W.W. Provinces, good draught horses, able to do hard work at a fair speed, are unknown. It is to be noted, however, that it is only the passenger traffic which is to be conveyed by horses.

38
of horses going a stage out and a stage back, or about 16 miles per day; a spare carriage would be required, and a spare pair of horses.

The capital expended would be—

<table>
<thead>
<tr>
<th>Carriages</th>
<th>Horses</th>
<th>Sattel Harness</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>12</td>
<td>10</td>
<td>£190</td>
</tr>
</tbody>
</table>

152,000 second-class passengers divided by 365, will give 416 as the daily number conveyed both ways. It will, however, be necessary to reckon upon some extra pressure occasionally; and carriage accommodation must be provided for, say 240 each way, or 480 altogether. Each carriage will contain 30 passengers, and will be drawn by two horses at the rate of about 6 miles per hour; travelling the same distance as the horses drawing the first-class carriages.

The total number of carriages and horses required for the actual work will therefore be 16 carriages, and 80 horses; but it may be as well to estimate for 20 carriages and 100 horses.

The capital expended, then, upon rolling stock and animal power will be—

<table>
<thead>
<tr>
<th>Carriages</th>
<th>Horses</th>
<th>Sattel Harness</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>100</td>
<td>16</td>
<td>£900</td>
</tr>
</tbody>
</table>

32,000 tons of goods may be put at 100 tons per day, or 50 tons each way.

Three tons may be allowed for each truck, and 34 therefore would be required; each would be drawn by 3 bullocks, 6 extra trucks might be allowed to meet casualties; and a few extra bullocks should be purchased. As the daily journey of a bullock may be put at ten miles, the distance of 41-25 would be divided into four stages; so that 12 bullocks would be required for each truck. 40 X 12 = 480, would be in daily use, or 500 to cover contingencies.

The trucks ought not to cost more than £100 each, and the bullocks £15 each.

The capital, therefore, expended upon the rolling stock and animal power for the goods traffic will be—

<table>
<thead>
<tr>
<th>Carriages</th>
<th>Bullocks</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>500</td>
<td>£750</td>
</tr>
</tbody>
</table>

The total amount of dead and live stock required for the conveyance of passengers and goods along a railway worked by animal power would be as follows—

<table>
<thead>
<tr>
<th>Class</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-class passengers</td>
<td>£120</td>
</tr>
<tr>
<td>Second-class do.</td>
<td>9100</td>
</tr>
<tr>
<td>Goods</td>
<td>7250</td>
</tr>
</tbody>
</table>

Total £217,500

Say £18,000.

The annual charge may be estimated as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest upon £18,000 at 5 per cent.</td>
<td>900</td>
</tr>
<tr>
<td>Wear and tear of carriages and repairs, 15 per cent.</td>
<td>9750</td>
</tr>
<tr>
<td>Cost of replacing horses and bullocks, 15 per cent.</td>
<td>7790</td>
</tr>
<tr>
<td>Repairs and replacing harness, 20 per cent.</td>
<td>250</td>
</tr>
<tr>
<td>Keep of 12 horses, at £2 per head</td>
<td>2688</td>
</tr>
<tr>
<td>Keep of 500 bullocks, at £8 per each</td>
<td>4000</td>
</tr>
<tr>
<td>Hire of 20 coaches, at £50 each</td>
<td>1000</td>
</tr>
<tr>
<td>Hire of 16 bulb drivers, at £10 each</td>
<td>1600</td>
</tr>
<tr>
<td>Repairs of stable, at 5 per cent.</td>
<td>1000</td>
</tr>
<tr>
<td>Telegraphy, charges as on locomotive line</td>
<td>1100</td>
</tr>
<tr>
<td>General charges, including clerks, &amp;c.</td>
<td>4420</td>
</tr>
</tbody>
</table>

Total £18,485

This sum, divided by the total distance of 41-25 miles, will give the charge per mile for traction £503 12s. 10d. and the general comparison between the cost of conveying the standard number of passengers and tons of goods per mile, on the three kinds of road, will be as follows—

<table>
<thead>
<tr>
<th>Type of Traffic</th>
<th>Standard Number of Passengers</th>
<th>Cost of Working</th>
<th>3% of Interest</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railroad</td>
<td>1313</td>
<td>302 12 10</td>
<td>157 3 2</td>
<td>£1400 6 0</td>
</tr>
<tr>
<td>Steam Power</td>
<td>1313</td>
<td>302 12 10</td>
<td>157 3 2</td>
<td>£1400 6 0</td>
</tr>
</tbody>
</table>

I have, in calculating the cost of working the animal power traffic, made an allowance for a variety of extra expenses; and for the fact that the steam traffic will be ample to cover the whole cost of working the line, and of paying an interest of 5 per cent. upon the capital expended. Under these circumstances, it is evident that, until upon any given line of road the amount of traffic very far exceeds that which passed over the North West line of railroad in the first half of 1863, it will be far cheaper to employ animal power than steam, in the movement of passengers and goods.

It remains to be seen what charge it will be necessary to impose upon the traffic, in order to cover the whole of the charges upon the road; namely, interest of capital, maintenance of way, and cost of transport. An analysis of the cost of conveying the different descriptions of traffic will show that the following is nearly the ratio of the outlay upon each

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-class passengers</td>
<td>£65</td>
</tr>
<tr>
<td>Second-class do.</td>
<td>£48</td>
</tr>
<tr>
<td>Goods</td>
<td>£54</td>
</tr>
</tbody>
</table>

and if the whole charge of £254 per mile be divided in these proportions between the different heads of traffic, the charge upon the first-class passenger must be such as would return £35 4s. 10d. upon the second-class, such as would yield £220 12s. 4d., and that upon goods such as would give £269 8s. 4d. Now the charge of £35 4s. 10d., divided by the number of first-class passengers, viz., 3200, would give 2'6 pence as the charge per head per mile. In the same way, £220 12s. 4d., divided by 125,000, the number of second-class passengers, would give 1'86 pence as the exact charge per head per mile; while £269 8s. 4d., divided by 32,000, would give 2'018 pence as the charge per ton per mile. A first-class passenger, however, might very fairly be charged at the rate of threepence per mile, and a second-class at a halfpenny, while the charge for goods might be put at 1'4d. per ton per mile; at these rates, with the standard of traffic the gross returns would be £558 18s. 4d., or £228 18s., in excess of the amount shown above to be sufficient to cover the interest of capital, maintenance of way, and cost of conveyance. Provision, however, has been made for the conveyance of upwards of 11,000 first-class passengers, 190,000 second-class, and 44,000 tons of goods without any extra charge; and the resultant traffic increase to this extent, the returns of the rate mentioned above would be—

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost per Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-class passengers</td>
<td>£137 10 0</td>
</tr>
<tr>
<td>Second-class do.</td>
<td>392 10 8</td>
</tr>
<tr>
<td>Goods</td>
<td>275 0</td>
</tr>
</tbody>
</table>

Total £888 6 6

And the profit upon the capital expended (which, at the rate of £367 per mile of road for construction, and £15,000 for each of 41-25 or £426 for live and dead stock, would amount to £30,000) would not be less than 13 per cent.

* Capt. Yule's estimate per mile for a cattle draught line, is only £1,317, of which £10 are charged to maintenance of way (not included above); £430 to wear and tear of rolling stock: £34 for hire of cattle, and the same for establishment, the cost per ton per mile being reckoned at 27 9. Mr. Hardy Wells in his report on the same line, estimated the draught expenses per mile of horse railway at £600 6s. 6d., and of a bullock line at £500 6s. 6d.

The great difference in these last estimates is in the number of animals estimated for, 2000 horses or 4000 bullocks for a line of 110 miles in length, being double the number set down in the present estimate for a similar length. Mr. Hardy Wells' calculation is for 150,000 tons of goods and 224,000 passengers, yearly; each passenger is reckoned at 8d. per mile, probably to include his luggage; as it is reckoned the average per ton per mile, would be 6s. 9d. for horses, and 12s. 6d. for bullocks. It is to be noted, however, that these estimates do not include any charge for the interest on the road and live stock, which probably constitutes the whole capital sunk. In the present estimate, deducting this item, and dividing the annual cost by the traffic, the cost per ton mile will be 781, showing a striking agreement between the three estimates, considering that all are worked out on totally different data.
ON THE CONNECTION OF PLATES OF IRON AND STEEL IN SHIPBUILDING, ESPECIALLY SUCH AS ARE SUBJECT TO SUDDEN TENSILE STRAINS.

By Nathaniel Barnaby, Assistant Constructor of H.M. Navy.

Much yet remains to be done to make iron shipbuilding a perfect art, and there is perhaps no one step remaining to be taken in the path of improvement more important than that of substituting the simple and positive means of connecting plates by welding, should it ever be discovered, for the present system of rivetting. The loss of strength caused by the present system is considerable in iron, but appears to be still more serious in steel. It forms, in fact, the great bar to the introduction of this most promising material into ships of war. I may give, as an illustration, two or three of the many examples which have been made by the Admiralty at Chatham Yard on Bessemer steel of the best quality. A piece of steel 4 feet long, and 12 inches broad, was cut from a half-inch plate, of which the proof strength was 33 tons per sq. inch. This piece was reduced to 6 inches in width at the middle, was supported at the ends by square pieces riveted, and most carefully connected. The plate should have broken at 82½ tons, and through the narrow part. It actually broke at 90½ tons, and then, strange to say, broke through the wide part of the plate, tearing away through the rivet holes. Thus while the material in the middle of the plate was at a stress of only 2½ tons per square inch, it actually broke through the holes at 16½ tons per square inch, or less than one-half the strain. In a precisely similar plate, differing from the other only in the fact that the rivets connecting the end pieces were 1¼ inch from the edge instead of 2½ inches, the plate broke in a similar manner at 73 tons, with only 15 tons per square inch of the plate broken. The holes in both these cases had been punched, and in order to ascertain whether these curious results were due to the injury supposed to result from punching, an exactly similar arrangement of plates was again tried, in which the holes were, as in the first 2½ inches from the edge, but were drilled instead of punched. The plate of the increased thickness now at 106½ tons, or 47-53 tons per square inch of the steel broken. I do not propose to draw here any inferences from the experiments detailed, or from the series of which they form part, further than this, that all which I propose to say concerning the necessity of bestowing greater attention on the connection gives strength of different modes of connecting plates intended to give tensile strength, is even more applicable to steel than to iron. Admitting, then, that for the present, at least, we must be content to connect iron plates by rivets placed in holes punched or drilled out of the material, and therefore by the sacrifice of a considerable portion of the strength of the plate, it is manifestly the duty of the engineer and shipbuilder to study to make this connection with as little sacrifice of strength as possible.

In every such connection the tensile strength of the plates across the outer line of holes, of the butt strap or strips across the inner line of holes, and the resistance of the rivets to shearing, should be all equal. Two plates may be connected, for example, by butt straps, as to reduce the strength of the plate by one hole only. The strength of the several parts has in this case been estimated on the assumption, verified by careful experiment at Chatham, that the shearing value of ½ Riveting rivet, including friction, and taken singly or in conjunction with others, is 10 tons, and that of rivets or other diameters is in proportion to the squares of the diameters; also, that the tensile value of the iron between the holes is reduced in proportion to the number of the perforations, and that reduction is about 30 per cent. when the holes are punched three or four diameters apart. This description of butt strap is of no value in shipbuilding, because the stronger and tie plates, to which it might otherwise be applied, have to be perforated between the butts by rows of holes to connect them with the beams. In such plates, in order to economise material, it is therefore desirable to reduce the amount of fastening at the beams as much as possible. I do not think it necessary to punch away for this purpose more than ½ of the iron; the remaining strength of the iron would then probably be ⅔ × ⅔ = ⅘ths of the whole, so that the straps connecting them should also give ⅘ths of the full strength of the plates. Any greater strength at the butts would, of course, be thrown away. If the butt
strap has to be caulked, this proportion of strength cannot be retained, as the rivet holes must then be placed nearer together. Let us take, for example, the connection, by means of a butt strap, of two plates, \( \frac{3}{4} \) inch thick and 12 inches wide, in which the rivets are 1 inch diameter, and are spaced three diameters apart. Then we punch out \( \frac{3}{4} \) of the iron, reduce the strength of the remaining iron about one-fourth, and have left only \( \frac{1}{2} \times \frac{3}{4} = \frac{3}{8} \). The tensile strength of the plate at 20 tons to the inch is 180 tons, and the tensile strength through the holes about 90 tons. If the connection is made by means of a single strap, the value of the rivets will be about 71 tons; and if by a double strap, say, 142 tons. No doubt this advantage is obtained from a second row of rivets in this case, unless the spacing along the edge could be increased. If the rivets are no nearer together than necessary for caulking, a second or third row could give no advantage, except in enabling us to reduce the thickness of the butt straps to less than the thickness of the plate, by reducing the number of rivets in the outer row where the butt straps are obliged to break. None of these considerations are new, but they have been so much neglected that those who are familiar with them will, I hope, justify me in thus restating them. But there are certain other considerations equally important, which have, I think, altogether escaped the attention of shipbuilders.

Let us suppose that we have a stringer or tie plate, the strength of which is, at the beams, and at the butts, \( \frac{3}{4} \) of the full strength of the plates, and that we have no means of increasing the strength at these points. Have we any means by which we can strengthen the plate at these weak points? Will this increase the tensile power of the plate? I think the answer would generally be, we have not—the strength of the tie will be measured by the strength of the weakest part, and this strength is fixed.

Now what I want to show is that this is not the case, and that we have overlooked an important element of strength, which is conducive to economy of material. Take the case of a stringer or tie plate crossing a number of beams, say 3 ft. 6 in. apart, at each of which the strength is reduced to \( \frac{3}{4} \) of the full strength of the plate. If this plate is brought under the action of a steady strain it is a matter of indifference practically how many such points of weakness there may be, and how much stronger the material may be lying between the weak points: But when strains are suddenly applied, we have to consider not only the number of tons required to break the weakest section, but the amount it would stretch before breaking. It is, in fact, the work done in producing rupture, viz., the force applied, multiplied by the distance through which it acts, which is the true measure of the resistance to rupture. Under these circumstances no elongation will take place in the strong parts of the plate lying between the beams: it will all be thrown on the weak points; and if any one of these be weaker in any sensible degree, the rest will be confined to the whole, to from 30 to 40 per cent. of the original strength of the plates. These lines of weakness occur at intervals of about 3 ft. 6 in., and between them the plate has its full strength, except where a butt occurs. The consequence of this is that, when the deck is put in tension, the stretching is confined to these weak places, and the amount of work which the whole combination is capable of doing before rupture is extremely limited. In order to remedy this state of things, I propose to remove all the wooden deck fastening from these weak places, and put it on either side of the beams. The number of rivets for attaching the plating I also propose to reduce. By this means a strength of plating is obtained across the lines of riveting of about three-fourths of the full strength of the plates. The next thing to be done is to reduce the strength of the plating between the beams to the same amount. This might be done by cutting holes in the plates, but instead of this I propose to omit the butt straps, and to have a continuous series of butts and plates in the proportion of one butt for every three plates. In addition to this reduction of material, I propose to leave intervals between the butts of about one-third the distance between the beams, so as to get long spans of uniform strength between the beams. The length of the intervals between the butts will be determined by the number of rivets which can be placed in the edge of the butted plate between the beam and the butt, as there must be sufficient to break the plate across the beam. A short piece of edge strip on the under side doubles the bearing value of the bolt, the breaking strain (gradually applied) is the same as before, but as the bolt will stretch one-fifth of its length before breaking, it becomes thereby less liable to rupture by a sudden blow, because, as already stated, the work done in producing rupture is in proportion to the weight or strain applied, multiplied by the elongation or the distance through which it is applied, and the whole is less when the bolt is broken by a sudden blow.

The details of one portion of these experiments were as follows:

Four bolts were taken, all made of best-selected scrap iron, for the purpose of the experiment, and all of the same diameter, viz., 21/2 inches; screw threads were cut in the ends of these, and nuts fitted. The other ends were formed with heads, leaving a length of 21 inches between the heads and the nut. The four bolts being thus as nearly alike in every respect as they could be made, two of them were reduced down on the anvil for a length of 4 inches in the middle of their length, to a diameter of 15 inch, which was the same as that of the iron remaining within the screw threads. The other two bolts retained the full diameter throughout. They were broken in the hydraulic press, with the following results, which are also shown in the accompanying photographs:

<table>
<thead>
<tr>
<th>Breakage Strain in Tons.</th>
<th>Breaking Strain in Sec.</th>
<th>Tons per sq. in. of this Sec.</th>
<th>Elongation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>B职es not reduced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 1</td>
<td>65</td>
<td>276</td>
<td>22.6</td>
</tr>
<tr>
<td>No. 2</td>
<td>69</td>
<td>276</td>
<td>35.0</td>
</tr>
<tr>
<td>B職es reduced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 1</td>
<td>64</td>
<td>1.67</td>
<td>33.33</td>
</tr>
<tr>
<td>No. 2</td>
<td>65.5</td>
<td>2.07</td>
<td>31.55</td>
</tr>
</tbody>
</table>

The fact that the strains of greatest magnitude in a ship are sudden in their nature, makes the principle under consideration one of no slight importance, because we see that by its application we are able to increase the time during which a given force must be applied in order to produce rupture.

As the material is disposed at present in iron decks, and stringer and tie plates, the plates are perforated in the lines of the beams, not only by the holes required for the rivets to attach the plating to the beams, but by the deck bolts which secure the wooden deck lying on the iron plating. The loss from the iron punched out, and the weakening of that which remains, on the whole, to from 30 to 40 per cent. of the original strength of the plates. These lines of weakness occur at intervals of about 3 ft. 6 in., and between them the plate has its full strength, except where a butt occurs. The consequence of this is that, when the deck is put in tension, the stretching is confined to these weak places, and the amount of work which the whole combination is capable of doing before rupture is extremely limited. In order to remedy this state of things, I propose to remove all the wooden deck fastening from these weak places, and put it on either side of the beams. The number of rivets for attaching the plating I also propose to reduce. By this means a strength of plating is obtained across the lines of riveting of about three-fourths of the full strength of the plates. The next thing to be done is to reduce the strength of the plating between the beams to the same amount. This might be done by cutting holes in the plates, but instead of this I propose to omit the butt straps, and to have a continuous series of butts and plates in the proportion of one butt for every three plates. In addition to this reduction of material, I propose to leave intervals between the butts of about one-third the distance between the beams, so as to get long spans of uniform strength between the beams. The length of the intervals between the butts will be determined by the number of rivets which can be placed in the edge of the butted plate between the beam and the butt, as there must be sufficient to break the plate across the beam. A short piece of edge strip on the under side doubles the bearing value of the
rivets, and allows about one-third of the distance between the beams to be omitted.

The advantages of one system over the other are, I think, the following:—

1. In the ordinary system one-fifth or one-sixth of the iron is punched away: by that proposed only one-ninth or one-tenth is punched and that cause a gain in direct tensile strength, to which must be added an increase of strength in the iron between the holes. These are together equal to about 12 per cent.

2. The strength of an iron deck under compression is limited, not by the area of section, but by its resistance to buckling between the beams. This being a secondary resisting element, is very small, since it is quite free to bend downwards between the beams. But by spacing the deck fastening, as shown, at intervals of about 2 feet instead of 3 ft. 6 in., the tendency to buckling would be reduced. The wooden deck would thus, both by its own direct resistance to compression, and by the support it gives to the plates, play a most useful part in compression, although it is powerless as against extension when in connection with iron. I therefore conclude that no loss of compressive strength is incurred by the holes in the plates.

3. All the holes for receiving the deck fastening may be punched, whereas if the fastening is in the beam flanges, the holes for them must be drilled either in the plates or in the beams.

4. The expense of cutting, fitting, punching, and rivetting butt straps is avoided. Where the material employed is steel, the gain is more considerable, as all the holes in the butt of the plates and in the strap have to be drilled to prevent the injury done by punching.

5. The weight of material omitted at the butts amounts to one-seventh of the whole material employed.

6. There is a gain in strength against injury and rupture by the action of sudden forces, the amount of which is not susceptible of calculation, but which, being in proportion to the extent of the spaces of uniform strength which have been introduced, I think very considerable.

The novelty of this proposal may be said to consist in so arranging the iron or other metal plates forming the flanges of girders, bridges, and other structures, or employed in decks, partial strakes are given, or, to use a slang term, a slip or vest, so as to make the tensile strength of the unperforated plates intervening between adjacent butts equal or nearly equal to the strength of the said intervening plates taken together with that of one of the butted plates where they are perforated, i.e., across the row of holes. The plates of the deck are placed parallel, and angle irons, stiffeners, or other iron framing, and by this means rendering the use of butt straps in such combinations unnecessary. In other words, a section through the plates between the beams or stiffeners is made to have, without butt straps, about the same tensile strength as a section through the fastening at the beams or stiffeners, for the purpose of forming spaces of uniform tensile strength not greater than that of the weakest place in the combination. In those intervals elongation will take place (to an extent depending on their length) before the materials can be ruptured, so that an increased amount of work will require to be done by the operation of a given force than in producing rupture. Also, in increasing the resistance to rupture under sudden strains in single plates, by reducing the tensile strength throughout certain intervals between the beams, angle irons, or stiffeners, and approximating to that at the beams, angle irons, or stiffeners, by cutting out portions of the plates.

I am aware that iron decks are not used in merchant vessels, although they are in all iron war ships built for the Admiralty, and I consider it to be false economy to substitute, for such decks or decks, stringers on the ends of the beams, tie plates near their middle, and diagonal braces between them; as I think it clear that from the round up to the beams, and other causes, a considerable portion of this material is unable to succour the rest when the top of the ship is put in tension or compression. The strength of wrought iron in extension and in compression is about the same, yet the bottom of the ship is usually made enormously stronger than the top. Some iron ships, indeed, have no top one. But I am inclined to think that the strength of the bottom, which might otherwise be made available in giving strength to the ship, considered as a floating girder, is thus wasted.

I indulge the hope that the economical considerations pointed out may be not only useful in lightening and strengthening ships designed for war, but in inducing private shipbuilders to introduce partial iron decks so formed into ships designed for commerce. I may, perhaps, be allowed to add in conclusion that these proposals do not form the subject of any patent.

ON THE SAFETY AND SEAWORTHINESS OF VESSELS.

(Continued from p. 129.)

Mr. W. SIMONS agreed with Mr. Smith that the topgallant forecastle was a very bad place for the crew. He thought that all the Atlantic steamers should be fitted with spar-decks for safety; but he ventured to think that something would be gained if the ports were abolished they would have a better class of steamer trading either to America or India. He believed if these were the case shipowners would spend more money on the construction of their ships, and they would have stronger vessels. For instance, it was well known, that the loss of the Amaliss, built on the Clyde, and the London, built on the Thames, astonished everybody but those who knew the reason why. He was of opinion that the London was 12 feet too narrow, that she ought to have been formed on a different construction altogether; and that if her owners had been her insurers she would have been a different vessel altogether. A ship for passenger service ought to have vertical beams, with diagonal stringers both above and below deck. He was convinced that the London would have been a much stronger vessel if her stanchions in the centre had been like those of the lattice girder bridge, instead of vertical. Then, again, the London had long plates, and perhaps as many as 600 vertical joints, whereas in a wooden vessel of her size there would perhaps not have been above one-tenth of that number. His impression was that the cause of the vessel founding was the sheet-glass joints gave way; and that in his opinion was the cause of the vessel founding.

Mr. R. BRUCE BELL asked whether that was merely a matter of opinion on the part of Mr. Simons, or was there anything in the evidence to show that the vessel had stood herself, as Mr. Simons had assumed? Mr. Simons believed that the cause of the loss of the London was quite conjectural; but his opinion was, that enough of water could not have got down her engine hatch to cause her to founder, but that she founded, as he had indicated.

Mr. MANSEL said that the London was very deep in the water to begin with, and she shipped a good deal of water, and sat down by the stern. She got the dead lights in her stern broken by the waves, and consequently would have a good deal of water there when she was in the river. When the stern lights were staved in, the water had free access to the cabin below by a large opening 7 feet by 4 feet in the poop, having no protection but an ornamental railing round it. In his opinion that was sufficient to explain her sudden foundering.

The PRESIDENT said he believed that they were not dead lights, but stern ports, that were broken in.

Mr. R. BRUCE BELL approved of sticking to the evidence in the case. With Mr. Mansel he had told them was brought out in evidence, but what Mr. Simons had said was his own individual opinion of what might have taken place.

Mr. FERGUSON said there was nothing in the evidence to show that the London had been straining at all. It was shown that when the engine was knocked away there was a hole left of about 13 feet by 10 feet; that the water would get in there before reaching the ports; that the deck would contain 100 tons of water before it got out the ports, which would put her 6 inches down; and that the stern windows being broken in, the water rushed in head and a hole about 7 feet by 4 feet, through which it poured into the lower cabin.

Mr. Simons did not believe that 100 tons of water could remain in the waist of such a deck for three minutes. It would have broken through the bulkheads.

Mr. FERGUSON said that she had a box waterway twenty inches high. He could not see how the water could have broken through those two thicknesses of plates—the one about 4-inch and the other about 3-inch thick.

Mr. GEORGE SMITH asked whether Mr. Ferguson had made any allowance for list?

Mr. FERGUSON said he had not.

Mr. Beresford remarked that he thought that would make a difference in the amount of water on the deck.

Mr. T. DAVISON said that the water on the deck of a ship rolling at sea did not run off so much as was thought, as the water partook of the motion of the ship, and the full area of the roll or list of a ship at sea was not obtained in displacing the water.

In answer to Mr. Simons, Mr. Mansel said that the London had five ports on each side.

Mr. Simons replied that it was impossible all those ten ports could have kept right, so as to retain all the water indicated.

Mr. Mansel said that not above two or three of the ports were in the waist of the ship, where the water was.
Mr. Booths remarked that the only case bearing upon the subject which had ever come under his notice was that of a screw steamer which he had projected some years since, and which had sailed from Greenock. In going into the North Channel she encountered a storm, and shipped a great deal of water, which drove the front of her poop in, and knocked a very large hole through the stern. She put back to Greenock in that condition for repairs. On inquiry of the captain of the ship, it was found that she had been a plain poop and forecastle, and that she was filled with water in the middle part; but from the fact that the front of the poop gave way and carried away part of the stern, she got free of the water, and in this condition came back. If there were properly a poop and forecastle, and she was made strong enough to resist any pressure of water to which it might be subjected, and also the bulwarks were strengthened, and afterwards went to sea, but was never again heard of; and to his mind there was no doubt that the ship would have stood the accident, but for the good workmanship of her builders. He had been in the habit of saying that it was unjust to ask the ship to do things which it could not do, not to give way, when struck by seas which filled her, as on the former occasion.

Mr. Robert Duncan said there seemed to be a great deal of speculation about the cause of the loss of the London. The survivors from the wreck were not experienced in the construction or form of the ship; but Mr. Barber, one of Lloyd's surveyors, gave important evidence. He stated that those things were managed better on the Clyde; and he said, particularly, that the engineers were so constructed that water on the deck would find its way out of the ports before it could "run down" into the engine-room. On that principle he had constructed the Pemomes and other vessels, so that the iron coaming or waist was well placed. The height was stated to be 150, or 150, of the bulwarks. He believed that was a very good plan. He thought it was expedient to carry this matter before the Board of Trade, as the Scottish Shipbuilders' Association had done before. On that occasion Mr. Moorsom had made some remarks in reference to what he (Mr. Black) had said as to the necessity of putting an end to that, but that was not now done, but to be allowed a proportion of space for the crew. Mr. Moorsom said that the thickness of the deck was sufficient compensation. Now, he maintained that that was not a sufficient percentage towards the tonnage of the ship. If a vessel of 5000 tons were placed, the percentage was only two per cent., whereas the allowance given for the crew space in the top gallant forecastle was equal to five per cent. Small vessels, also, did not proportionately benefit in that way. By the present system all large vessels were greatly favoured. But a larger question raised by Mr. Fergusson's paper, the importance of which cannot be over-estimated, and that is, does the registry law stand in the way of improvement in the building and equipment of ships? Mr. Ferguson seems to think so, and if his views are sound, he admitted that the Act of 1854 required amendment. He was aware that the rules which govern tonnage influence to a great extent the arrangements of shipowners and shipbuilders, and have always done so; for previous to 1854 every change in the tonnage laws produced a change of form, of ship adapting itself to the law, so as to insure the greatest amount of carrying capacity on the smallest registered tonnage. But the Act of 1854 applied a remedy to this evil, because, as far as the under deck of 1000 tons is concerned, no doubt that it is a sound one; but like others productions it had defects—it was not perfect; what law ever was? It provided that nothing should be added to the tonnage for any closed-in space on deck occupied by the crew unless such space exceeded 1/20th of the gross tonnage of the ship; but from this allowance all vessels were necessarily excluded, since they have their crews on deck. Now, he thought that it was amply clear that it was unfair to give to any one class of vessels of which other ships could not avail themselves; and it was equally clear that this provision had led to the deck arrangements of which Mr. Ferguson complains. It must be confessed that spar-deck ships are hardly dealt with, and that the penalty paid by the owner for joining his topgallant forecastle and poop by a flush deck is heavy, and has no doubt deterred many under deck of 1000 tons from adopting that arrangement. As long as we offer so large a premium for the erection of deck-houses, he feared we shall have them built and fitted to a dangerous extent; but withdraw the premium, and the practice would die a natural death. There is working under deck of 1000 tons demands a number of classes of small sailing vessels engaged in the coasting trade. Now, as all dues and port charges, including towsage, are levied per register ton, it follows that all small vessels are compelled to pay £5 per cent. more than they are entitled in justice to be charged with. He need hardly say that there are no vessels afloat that have so many difficulties to contend with, and no capital that pays so small a per-centage as that invested in coasting vessels. He therefore concluded that cockers are not likely to deal from the coasting trade as they should be dealing in that space. But there is a higher ground from which he thought this subject should be looked at—the sanitary condition of the sailors that man our coasting craft. He knew from personal observation that the space allotted to them is so small that neither cleanliness nor comfort is possible, and there is no argument of any advantage in the coasting trade, that is, "we cannot afford more room." He would remedy this by extending the allowance for crew space to all vessels, whether berthed on deck or not.
making provision under heavy penalties that the space allotted to each of the crew should be similar to that provided for a steersman passenger. These men have strong claims on our sympathy, and he submitted that this institution is entitled to be heard in their behalf. He also thought that engineers and shipbuilders are entitled to consider and pronounce an opinion on the still more important question of spar-deck ships, as contrasted with that class of vessels referred to by Mr. Ferguson, and he was quite of opinion that considerable suggestion will receive due consideration in the proper quarter.

Mr. Simons said that no one would question the propriety of having the spar decks free of dues, with regard to the spaces not used for stowing cargo, and that it would be a great advantage to the passengers. Mr. Costello replied that that part of the matter would be very easily settled. He would grant exemption from dues for it on the same condition as a ship without such a deck, provided that nothing was stowed in the passages; and in regard to small vessels, he would require that each ship should have the same space allotted him as every steersman passenger had.

The President held that the covering of those deck holes was just like the privilege granted to vessels of the same class as the Iona.

Mr. Costello, which he believed with the attendance with some effect. He believed that if the matter were placed before the Board of Trade it would be settled satisfactorily.

Mr. J. A. Allen did not think there could be any doubt as to the superiority of a four-deck ship over a three-decker. The object his firm had in view in putting in a fourth deck was, that in going through the Northern Atlantic the passengers might get exercise in bad weather when they could not get on deck, and they thought they had got as much accommodation for passengers as they could expect from them in order to build them. Accordingly, they contracted to build two of that description. When they got one finished they found that the gross tonnage was so much more than they expected, that they overcharged the order for that ships. The result was that the fourth deck was the same as the third, and the effect was that, although the latter was 9 feet longer and 1 foot broader than the former, yet she was 300 tons less register! Consequently, they paid about £2500 a year less dues for the larger vessel. The fourth deck gross tendered to regulate itself accordingly. He alleged that all parts of humanity there was great reason for an alteration in the law. He thought that, if the matter was properly represented, there was scarcely a chance of a refusal. With regard to carrying cargo in those spaces, he was of opinion that no one would try to do so; and if the load-line were set at any height, Mr. Carrington would not carry cargo could not be put there, for it would be damaged by the water, so that that objection was easily disposed of. He suggested that a committee be appointed to draw up the heads of a memorial to the Board of Trade, and that all parties seemed to be agreed that no change should be made on the measurement for any advantage that is to accrue to passengers on a ship; and what he would suggest to that institution was, that they recommend that every part of a ship, no matter whether it be unoccupied in the height, should be made to make an allowance for the accommodation of sailors. Make a distinction between what brings revenue per se, and leave the rest free to benefit the crew.

Mr. R. Duncan suggested that the Board of Trade should be recommended to measure every part of a ship that was included, whether it was on deck or below it, and that they give an allowance on the gross tonnage for the crew. At present the shipbuilder had to build tons of space for which possibly he was not paid, it not being measured; hence he thought it would be better if the whole vessel were measured, galleys, water-closets, topgallant forecastles, &c., and a fair allowance made for crew-house. At present a great portion of the deck-houses, forecastles, &c., were left to thesurveyor to measure or not as he thought proper.

Mr. Costello said that Mr. Duncan was in error if he supposed that it was optional to the surveyor whether he measured some spaces or not. The words of the act were every permanently closed-in space, whether it be intended for storing cargo, passengers, or crew. No, among the spaces referred to by Mr. Duncan were those over the hatches, steam winches, and others, which were sometimes fitted with sliding bulkheads, which were run out and in as required; but the surveyor had no power to consider them, and he did not think they were used. Mr. Simons did not admit that such deck spaces, if covered in, would not be used for cargo. Many things in the East India trade might be stowed away in them.

The President said that he thought Mr. Duncan wished for the full measurement, in order that shipbuilders might be paid for every registered ton they supplied.

Mr. Duncan thought it would be the fairest way for all if the whole vessel were measured. The builder would know what he was giving and the owner what he was getting. That would do away with the great difference apparently in tonnage, as shown by Mr. Allan.

Mr. George Smith, jun., said Mr. Costello seemed to say that 5 per cent. would be a full allowance for the crew. He would suggest that in any memorial sent up to the Board of Trade they should stipulate that the crew should get the benefit of all such allowance. Then, with regard to the spar-deck, he agreed very much with Mr. Simons' opinion, that there should be a distinct proviso that no cargo should be put into such excluded places. He did not think any deduction should be made for cabins or pantry, but it ought to be considered in the tonnage which was for the exercise of steersman passengers. Let the whole be measured, and an allowance made for the crew space and what was required for the comfort of steersman passengers. The rate per ton which built comfort of the passenger and had no use for carrying cargo, and nothing be added for the closets, galleys, or washing-houses for female passangers.

The President said the memorial must be presented without much delay, if it was to have effect; it was impossible to commit themselves to acting. Mr. Hunt thought there was no time for that. He would leave it to a committee. He seconded the President's motion.

The motion was carried.

Mr. Allan then proposed that the following be appointed a committee to draw up a memorial to the Board of Trade on the subject:


Mr. R. Bruce Bell seconded the motion, which was carried unanimously.

Subjoined is an extract from the Memorial sent on the 3rd of April last, by the Institution of Engineers in Scotland, to the Board of Trade:

"This institution having learned that your Lordships are at present legislating on the subject of Tonnage in a Bill now before Parliament, prepared a memorial, as follows, for your consideration: "

This enactment furnishes an inducement to provide the accommodation for the crew in closed-in space on the upper deck, such as topgallant forecastles, and deck houses, because the tonnage of such spaces is not included in the measurement of the ship, and is not chargable with dues for docks, lights, or any purpose whatever.

In large ships, which trade in warm climates, the seamen can be, and are comfortably quartered in closed-in spaces on the upper deck; but in such vessels such spaces are provided on the upper deck, due regard to sea-worthiness; and in any vessels which trade to cold climates, the seamen cannot be placed in topgallant forecastles without subjecting them to severe discomfort. Thus those vessels which, for sea-worthiness and the protection of the seamen, have the forecastle under the upper deck, and of which the measurement is included in the register tonnage, are subjected to the payment of dues on the tonnage of the ship space. We are not aware of any substantial reason that can be urged for this exemption, nor is there any reason, excepting in the case of the sea-worthiness of the ship, nor to the comfort and safety of the crew; nor can we imagine that it can be urged for one moment, that a ship with the crew space under an upper deck should pay less deck dues than a ship with that accommodation which the ship is not chargable with dues for docks, lights, or any purpose whatever.

We beg your Lordships most respectfully to consider these statements, and we cannot but express not only a great desire, but a strong conviction that you will place your Lordships in the most desirable position of two large ships, the London and Amalthea, attended with the most lamentable results, furnish our reasons for addressing your Lordships on.
another provision of the Tonnage Laws, operating to the great injury of ships as well as to the danger of passengers.

With this letter, we beg leave to submit a drawing of a ship, showing an arrangement that is not unusual for passenger steamers. According to this plan, there is a poop, a topgallant forecastle, and a range of houses extending nearly from the poop to the forecastle, and all forming closed-in spaces on the upper deck. In such ships, the space forming the main deck is reduced to an extent not exceeding one-twentieth of the remaining tonnage of the ship, the cook's-galley, the water-closets, &c., are not included in the register tonnage of the ship; but if these are covered over with a closed-in deck, they are at once included in the register tonnage, and reflect the ship's strength and thickness of its walls? These are a few, but a few only of the questions which a study of the light and shadow of a building presents to the mind of the architect. The tendency of the present style of architecture in England has been rather towards technical excellence than the improvement of the great principles of design. Nor are the causes of this far to seek. The revival has had its origin more in the individual spirit and energy of private persons, than in any Government influence. The Church, the oldest and most efficient supporter of the art, but here, too, the tendency has been to smallness and prettiness, rather than to size and magnificence: true, indeed, our cathedrals have undergone, to no insignificant degree, restoration and improvement, but it has been in the embellishment of the superstructure rather than in the extent of the building. Here, too, we observe that not the church of the art, rather than the corporate idea, that has had its main influence upon the public mind. The parish church or the nobleman's mansion has been the scene of the architect's most successful labours. Of course, to this rule there are large exceptions. The vitality which has risen from individual energy and individual wealth has spread through every part of the body politic of England, and we have seen with our own eyes the erection of many noble public buildings of which no age or country, not even classic Italy, need have been ashamed; yet I dare affirm that the movement has been inspired from below rather than from above, as the result of the age. The taste has spread from the labours of such men as Rickman, and Pugin, and Ruskin, rather than gained inspiration from public patronage, from the Government, or from the Crown. The consequence is, that our efforts, our experiments, are necessarily upon a small scale at first. We are like military officers who have not been called upon to lead an army in large bodies of men; whereas, abroad, painters, sculptors, and architects generally, have much assistance from government, put themselves at the head of a large set of young men, and form a school, whether of painting, or sculpture, or architecture. We in England work in an isolated and therefore comparatively small way. Here and there, our young architect or sculptor may have pupils; a painter, we may say, hardly ever.

Nor do I feel that this mode of working is altogether wrong. It interposes great difficulties in the way of struggling merit; but, on the other hand, those choice spirits who struggle upwards are probably men of higher genius than those who in the neighbouring country are raised up under the fostering wing of Imperial patronage. We have nothing to be ashamed of in the artists of our day. Finish, indeed, perhaps, bears a disproportional value in the market, and the excellence of detail, whether in architecture or its sister arts, is very highly appreciated; while a work of that of a Manet or a Degas is thought of.

I mention these topics of the day as one excuse for recalling to your minds a few of what I would call the larger principles of the art,—its theory rather than its practice.

I would, then, ask you what is breadth? It is a word frequently in the mouth of the artist, but, perhaps, not readily present to the mind in any very clear and definite manner. Perhaps we may arrive at a sound notion of its nature by looking at its opposite, which I take to be "spottiness of effect," or "overflowing of detail." As a general rule, we may say that the earliest styles of Gothic art, the Norman, the transition from Norman to Early English, the later transition from Early English to Decorated, present noble examples of breadth and simplicity of treatment, when compared with the Perpendicular in England, the Flamboyant style in France, and the Renaissance in Italy. It has been observed by a writer on morals, that we do not want a dinner to be "all sweets, or all savoury, or all "beautiful," but a "well-balanced" dinner. So, too, we do not like a building entirely covered with ornamentation, which justly is compared rather to "galloree-work, or lace-work," than to the realisation of that noble idea of structure which makes the framework the basis of all real beauty, just as the bones of an animal are the true foundation of its features and form. Not universal, perhaps, but ornament in the right place, in the right degree, and, above all, in the right perfection, are characteristics of breadth. With breadth is necessarily connected severity of style; and I would add this one observation upon the subject, which I think, is agreeably to a great extent in Mr. Buckler's "Greek and Beautiful." Breadth seems to be necessarily linked with size, and what may be called a certain masculine vigour in the de-
sign of a building. Small things are deprived of much grandeur, and its place is then supplied by the secondary attribute of prettiness or elegance. I would instance, as a proof of this, a small apartment as compared with a large; a lady-chapel as compared with a nave; metal-work as compared with stonework; the Parthenon as compared with the iron-works. The three minutes of the object, the less useful we fear that exquisite finish upon it will be contrary to the rules of taste. The dragon-fly or the humming-bird has colours more brilliant, hue infinitely more delicate, than we find in the plumage of the dusky eagle or tawny coat of the lion. Small things can hardly be too pretty; large things are not so. As lawyers use, the less slow we are in mind, I think much useless expense might be spared. Size in a building in no small measure supplies the place of ornament. There is dignity even in empty wall space. On the other hand, in small chapels, in the tombs of the wealthy, in the heredities, in the font, in the memorial stones, we have good examples where the true principles of simplicity and vigour may, with great propriety be made to yield the palm to loveliness and grace.

Breadth, then, is always accompanied by grandeur.

Those Titanico fabrics, Which Phidias flung his plumes to times that have
No other record,
are noble examples of this; and as we sail down the stream of time, and advance in knowledge of world architecture, the Doric temple presents to us the noblest example that can be found of "breadth." Ornament, varied and rich, is confined to the pediment, and the pediments of the roof, all useless and without intention, unless surmounted with sculpture. We may notice too, how accurately the principle of ornamenting "structure" is carried out. The ornament being almost always placed upon some essential part of the building, and not seldom super-added, is necessary, not decorative, and the variety of form, too, which characterises this Doric style is marvellous. We may first of all observe the form of the building—a parallelogram or oblong. The cornices, the triglyphs, the bases of the columns, the steps leading to the portico, are all square in outline, and notable for the saliency of their right angles. The columns are all circles, and being circular present the finest contrast to the square masses of which the building consists; but the adjuncts of these noble shafts, the fluting, and the capitals present the form of delicate curves. The capital is ovoid. It used to be assumed that these columns were bounded by straight lines. Modern discovery has shown that they have a convex profile,—this in the columns of the Doric, and to a more pronounced degree in the column. The absence of this in modern work gives that poverty and rigidity to the style,—in other words, that want of breadth,—which is so frequently matter of just complaint.

We see, then, that although the Doric order is remarkable for its symmetry, its breadth, what may fairly be termed the opposite merit, variety of form, complexity of detail, and other absent from the mind of the Greek artists. Variety, indeed, may be said to be the note of the picturesque, as symmetry is the note of what is pure and simply beautiful. It is in the combination of the two that we have the same, not only of architecture, but of a great part of art.

Another refinement was to give a slightly-inclined inward slope to the whole building. This, of course, brought out a great notion of support and strength. Each curve was designed upon principles truly mathematical. The care with which the mason-work was built has never been surpassed; and yet all this masonic effort, even the least part of it, was bestowed upon a design at once simple, appropriate, and beautiful. The probability is that all these splendid temples were not only remarkable for their lovely forms, for the depth and play of light and shadow on the rounded column, and in the carvings and the precious stones, distinguished even at a distance by their sparkling colour. This topic, however, is scarcely within the scope of this lecture. I hasten onwards to notice some few other examples of breadth of treatment, as it is called, of which the pure Doric sample may fairly be termed the most natural and perfect form.

Taking a bold leap, as it were, from Pagan styles to Christian art, we perceive an unmistakable analogy in their progress and development which can hardly escape the notice of any intelligent inquirer. The social state of man as he emerges from barbarism into civilisation, develops, at various periods, in the Pagan and Christian arts, in a manner similar to the different ages of Greece and the Greek, and it is as superior to it as the character of its great Founder was to that of Socrates. Nevertheless, there are points of likeness, and if the theocratic system of the kingdom of Israel was intended (as most orthodox divines admit) to prefigure the sacerdotal and sacramental system of the Christian Church, the difference was that the Christian Church was, we must look to ancient Rome as the fountain of all systematic laws, and what may be comprehensively called the organisation of civil society, to Greece we may confidently turn (as an able statesman has lately told us) as the divinely-appointed source of our knowledge in all matters of taste, literature, poetry, and art. The Indo-Germanic races which descended into Italy proper, from Thessaly, from Thrace, from Scythia, were but men of like passions and kindred origin with those who, many centuries afterwards, came down from Germany and France into the plains of Lombardy. It is therefore not unnatural, upon the principles of Greek architecture, some faint likeness of the early styles of Christian art, and that, mutatis mutandis, we should see in Doric simplicity a prototype of Norman breadth and grandeur, a prototype undoubtedly more perfect in all technical excellences than its Christian successor, but less fertile in ideas, in variety, in the friendship that the Frenchman tells us the French style discloses. How simple, and yet how perfect, are those forms of heroes and horsemen which came from the inspiration of a Phidias. Sculpture, indeed, always was used as an adjunct of Greek art in the days of its true glory. Not merely the frieze, but the metopes between the triglyphs. The pediment, as before noticed, and the pediments on the roof, are all useless and without intention, unless surmounted with sculpture. We may notice too, how accurately the principle of ornamenting "structure" is carried out. The ornament being almost always placed upon some essential part of the building, and not seldom super-added, is necessary, not decorative, and the variety of form, too, which characterises this Doric style is marvellous. We may first of all observe the form of the building—a parallelogram or oblong. The cornices, the triglyphs, the bases of the columns, the steps leading to the portico, are all square in outline, and notable for the saliency of their right angles. The columns are all circles, and being circular present the finest contrast to the square masses of which the building consists; but the adjuncts of these noble shafts, the fluting, and the capitals present the form of delicate curves. The capital is ovoid. It used to be assumed that these columns were bounded by straight lines. Modern discovery has shown that they have a convex profile,—this in the columns of the Doric, and to a more pronounced degree in the column. The absence of this in modern work gives that poverty and rigidity to the style,—in other words, that want of breadth,—which is so frequently matter of just complaint.

It is not impossible that the analogy I have noticed between the early Doric and the Norman might be carried further. There is in the Ionic style a character of elegant simplicity which is not alien to the Early English; and in the richness of the Corinthian a great likeness to the Gothic Decorated style. These may be feeble analogies—I will not too much insist upon them; and yet, on the whole, they appear to give a fair view of the various steps by which the human mind rises to the ideal of architecture from rude stone to costly marble, from simplicity to richness of decoration; after which the course is generally downward; not, as has been before observed, in technical skill, but in all the grander attributes of art. As labour becomes more skilled, we economise our materials; and we therefore find in later periods of development less of severity, less of power, but more minuteness and elegance of finish.

Again, we may, perhaps, find it useful to compare our condition with regard to architecture to that of Imperial Rome, where the Roman type, which was afterwards to become the Gothico Romanesque, to the Gothic and the Renaissance, as the Gothic and the Renaissance became the French, and the French type as it is called, by some, as the type of our own age. And we see that in the Roman type, as it is called, the first indication is that it should be simple, and yet distinct, and yet rich; that the rich should be not too rich, distinct without being too distinct, and yet rich, by the richness of the decoration. After which, the course is generally downward; not, as has been above observed, in technical skill, or in the grander attributes of art. As labour becomes more skilled, we economise our materials; and we therefore find in later periods of development less of severity, less of power, but more minuteness and elegance of finish.

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Again, in country, I have, perhaps, find it useful to compare our condition with regard to architecture to that of Imperial Rome, where the Roman type, which was afterwards to become the Gothico Romanesque, to the Gothic and the Renaissance, as the Gothic and the Renaissance became the French, and the French type as it is called, by some, as the type of our own age. And we see that in the Roman type, as it is called, the first indication is that it should be simple, and yet distinct, and yet rich; that the rich should be not too rich, distinct without being too distinct, and yet rich, by the richness of the decoration. After which, the course is generally downward; not, as has been above observed, in technical skill, or in the grander attributes of art. As labour becomes more skilled, we economise our materials; and we therefore find in later periods of development less of severity, less of power, but more minuteness and elegance of finish.
her consular and republican history, of which latter we have not, as far as I am aware, a single memoir, but with the conquest of Carthage, the subjection of Greece and Egypt, the expansive Oriental dominion, artistic wealth began to flow in upon her from all quarters. The consequence was a number of buildings of different and incongruous styles; remarkable rather for size and grandeur than for taste, and a masculine vigour of style. The same may be said of our real cities of art. For Augustus it was remarked, that having found Rome a city of brick, he left it a city of marble. The Emperor Napoleon, in like manner, having found Paris a city of streets, narrow, inconvenient, and dirty, has made it a city of palaces, airy, commodious, and clean; but it is a general and true remark, that in doing all things as large as in his main and the whole dignity of imperial Rome, we can hardly suppose that the Romans saw (it is a philosophical remark of Mr. Fergusson's) the result to which the amalgamation of various styles then in vogue was tending, and yet they worked as distinctively to that end as if the spirit of prophecy had guided them to a well-defined conception of the subject as a whole, and in the same time that in which the spirit of prophecy has guided us. We have only to compare the effect which the spread of the Renaissance in all its various phases had on the architecture of the world, and we shall be constrained to confess that magnificence often means monotony, and costliness a sacrifice of individual freedom. In London matters are little better; though they are better. If Paris, like Rome of old, is delivered to the tender taste of an emperor, London is being gradually given up to the ostentatious display of the engineer. In all this we see tendencies towards a state of transition from old and time-honoured styles, to something new, something better, it may be, than the world has yet seen; but whether worse or better, it will probably be something which when in its main it becomes a part of the dignity of imperial Rome, we can hardly suppose that the Romans saw it (it is a philosophical remark of Mr. Fergusson's) the result to which the amalgamation of various styles then in vogue was tending, and yet they worked as distinctively to that end as if the spirit of prophecy had guided them to a well-defined conception of the subject as a whole, and in the same time. 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whole spinal marrow, as it descends from the brain to the pelvis, is enclosed in a strong, compact arch, to which the spines of the back act as a powerful keystone. But if the principle of the arch is to be found in the body of every animal, we may discover likewise that of the column, or vertical support. No superfluous material is to be spared by the architect: an elephant is well proportioned to sustain the enormous weight of his unwieldy yet majestic frame; while that of the camel or giraffe is slender, elegant, and bony, just in proportion to the superincumbent mass that presses upon it. Look, too, at the feet of the smaller animals; the feet of the elephant, like the other feet of the human being, are well marked indelibly in the hipbone; the foot of the elephant, like the foot of the human being, is well marked indelibly in the ischium, or stirrup bone, to support weight. The foot of the camel is not arched at all, but flatly, horizontally, spread out, with soft, large cushions at its sides, to prevent the animal sinking into the sand of the desert. But Nature is as thrifty an architect in the choice of her materials as in the forms in which she uses them. I select the following passages from a work of Owen:-"The bones of the fishes are spongy in the interior; and where ossification takes place it is restricted to the surface of the primary gristy mould. The bones of the turtles and sloths are solid; but in the active land quadrupeds the shaft of the long bones of the limbs is hollow; the first and second vertebrae having been absorbed by the younger architect, is being deposited from without. The strength and lightness of the limb-bones are thus increased, after the well-known principle of Galileo, exhibited by means of a straw picked up from his prison-floor, to answer a charge of atheism brought against him by the Inquisition. The bones of birds, especially those of powerful fowls, are remarkable for their small size; this is due to the double function of the bones of the bird, he concludes"—The bones of these birds are filled with rarefied air. Their extremities present a light, open network of slender columns shooting across from wall to wall, these little columns being likewise hollow."

Every book that is written on natural history gives us something in the nature of a definition of what is meant by the word "question," mentally uttered by my auditors, as if such arguments were foreign to my lecture. I must excuse myself by saying that, as Nature does everything with a clear and definite purpose, or final cause, the architect ought to do the same; and that the vegetable world as well as the animal kingdom offer most excellent subjects for the study of the young architect, subjects hardly secondary, if at all so, to the study of the works of man, the temples of Greece, or the Medieval cathedral.

The principle of the hollow column, which I alluded to in the earlier part of my lecture, though well known to the engineer, has seldom, in its outlines or results, been sketched out by Mr. Butterfield, indeed, has used it in the Church of St. Alban, where the decorative columns are of hollow pottery, not unlike draining tiles. The effect is pleasing. I observe, too, that Mr. Barry has used the same contrivance for ornamenting the corners of some schools in Holborn, and has adapted these hollow tiles to convey water from the roofs of the buildings. It is when we come to the higher region of the air (like the bird) that we may naturally expect to see bird-structure, if I may coin a word, imitated. What is the spire itself but a hollow tube? and it is in the building of spires that hollow tubes, as I conceive, might very effectually be introduced, as being good examples of a combination of the external and internal parts, in the sense in which we mean. As English builders are very defective in,—I mean altitude of proportion. This quality is necessary to grandeur, particularly in the Gothic style, and in edifices dedicated to the glory of God.

It is then in that variation which admits of the special adaptation of each form to the purposes for which it was designed, that we see the wisdom of nature, or, in other words, the wisdom of God. Why should not the same law guide us in our buildings? Pugin has well defined architectural propriety to be, that the external and internal appearance of an edifice should be illustrative of, and in some degree agree with, the purpose for which it was designed. The animal, the tree, or the flower, each has its own character. So should the building designed for God's glory, the collegiate establishment, the town-hall, the mansion, or the cottage. I need not point out how contrary to this wholesome principle is the idea of having a church like a Greek temple, with a Doric colonnade, a collegiate establishment like a large hotel, a town-hall like a theatre; a gentleman's house like a barnyard, or little better, a Gothic abbey; or an entrance lodge decorated with an Egyptian Sphinx. There is a place in Nature for everything, and everything should be in its place.

... We must beware of our rule being too small than to great things. It gives true simplicity and breadth of character, and cuts off useless ornamentation. It is allied to the equally important principle that ornament should never be introduced for its own sake, or as we may express it, for mere "show-off," but should be confined to the decoration of constructions which require it. The vegetable kingdom is subservient to some purpose, and beauty is superadded. How different is this from the faulty decoration of the upholsterer, who determines to do the thing in the Gothic, the Greek, the Italian style, or in what may be called a skilful medley of the worst features of all these, the upholsterers' style: crockets and finials may be thrust every corner; here the claw of a beast, there the beak of a griffin; here a sideboard supported by a mahogany eagle, there a serpent twisting gracefully round the table's leg. Where, I ask, are simplicity and breadth in these things? Truly did Mr. Pugin remark, that a gentleman could hardly walk through a drawing-room without danger either to the furniture or to his own clothes.

Mr. Pugin remarks, "Notwithstanding the palpable impracticability of adapting the Greek temples to our climate, habits, and religion, we see post-office, theatre, church, bath, reading-room, hotel, Methodist chapel, and turnpike-gate, all present the sameness of a Greek temple outraged in all its proportions."

A few words may be added on variety, not merely considered with a view to the various purposes for which buildings are designed, but as in itself a principle of beauty, and a main source of the picturesque. Inequality of forms and quantities is necessary to make an agreeable building or picture. It has, I think, been remarked with great truth, that the effect of the opposition of lines and the force of contrast is more noticeable in a work of art than in nature; for in the former the various objects strike upon the retina at once, in the latter they are divisible. Whatever may be Mr. Pugin's photograph, which would not strike the most delicate or critical eye in nature. To show what I mean, I have taken the trouble to draw out, as a diagram, the hand of a man and the hand of a monkey. Teleologically, that is, with the view of studying the purpose for which each is framed, they are equally well adapted to the purpose for which they are intended. The hand of the human hand, with what delicacy and variety the length of fingers is gradated; how much more subtle the difference is in the size of the finger joints, and how this infinite variety of size contributes to beauty. The same may be said of the graceful and awkward features which are the result of the development of the organism. I will, just for example's sake, give another illustration, from the animal kingdom—a rose and a convolvulus. The forms are equally lovely, yet both dissimilar; and if we examine the parts with care, we find no two leaves, no two petals, no two parts of any description, like their fellows. The flowing curves of the floral kingdom may be a study more congenial to the painter or the sculptor than to the architect, who deals in general with stiff and unyielding materials. In the midst, however, of these lovely curves, within the calyx, and often round the corona of the flower, there are exquisitely symmetrical forms—hexagons, pentagons, octagons,—every conceivable geometrical form. It is this part that the architect would be most serviceable to the architect. From their illuminated manuscripts, from their being great farmers, &c., we may well believe that the monks of the Middle Ages not only studied botany, but adapted it to their building purposes; and if we add the analogies of the words and the analogies of the names, one beautiful feature in our Gothic cathedrals is the fruit of this research. I allude to the rose window.

I exhibit as an illustration of the same principle two houses of the commonest street type; No. 1, entirely unornamented; the second such as seen in a better kind of street, with at least a show of taste upon it. Why is one superior to the other? Both are equally symmetrical; but in No. 2, superadded to the symmetry, there is a show of variety,—of variety in the forms, and variety in the quantities. I should be glad if any one could point out any other difference to account for the extremely different effect of the two designs upon the eye. The next
example I exhibit is from Welford Church, Berkshire. These elevations are taken from a print, and are both somewhat modified: In No. 1, the height of the tower and spire exactly coincides; in No. 2 it is different. Referring, in the next place, to the segments of the tower, we find them in No. 1 precisely equal, in No. 2 quite unequal, even uneducated, even I imagine, see that No. 1 is superior in all respects to No. 2. Nor can I assign any reason for this superiority, unless it be the application of that law of variety which, as I apprehend, arises originally from the necessity of resorting to various means for the same ends, as the test of the carriage and purpose, those of the roodina for another; but which becomes, secondarily, a principle or law of beauty, independently of any purpose which the Author of nature may have had in view. I exhibit a drawing of an arch in Canterbury Precincts. The point here is the exquisite manner in which vegetation accommodates itself to buildings. The elms are hardly suitable to this point. A grass lawn, such as England, and England alone, can boast, is the most beautiful platform from which any building can spring. Trees, shrubs, and ivy—even dangerous ivy—have their beauty, and are valuable adjuncts to architecture.

I would now, before concluding, call your attention to the diagram above my head, in which I have ventured to reproduce my general views on the subject of the arts and architecture particularly. You will observe, it is divided into three heads—form, height, and shadow and colour; or we may call them outline, substance, and colour, for light and shadow are the most refined and bounded form.

Under the head of “Form,” you will observe that I have taken the Doric temple as the example of symmetry, and the Gothic cathedral as that of variety in form. They are perhaps as good as any we might chance to hit upon. I would observe, however, that the symmetry of the Doric column is diversified by an almost infinite variety, and that the variety of the Gothic minster is modified by a large share of symmetry. Perhaps it would be fair to assert, that in Gothic art the principle of exact correspondence of parts is changed for that of a general balance between the two sides, so to say, of the picture. This is well exemplified by the position of the central tower in Canterbury and Lincoln. To the east, we always have the most interesting part of the building. Here, owing to its sacredness, the largest amount of decoration is always to be found, both externally and internally. Deep shadows throw out the surrounding chapels, and were terminated in a “chevet,” this portion of the edifice is generally full of interest. To balance this mass of darkness, the great length, and the quiet stateliness of the nave; yet even these fail to give their due share of importance to the western parts of the building, for the typical completeness of which two western towers are an absolute necessity. I offer my humble adhesion to Mr. Fergusson and Mr. Lichfield, who has its central two towers of its central two spires, though small in size, a thoroughly artistic group. Canterbury, of which I exhibit a lithograph, only moderately well done, is a good deal too long.

If we recognize in any measure the truth of the principles developed in this lecture, we shall in some degree, at least, understand why we are greater and yet less, less and yet greater, than our ancestors. As has been most eloquently remarked by the Dean of Westminster, “We cannot dispense with the mighty past, even when we have shot far beyond it.” Those who follow cannot be as those who went before. Medieval days, with their ever growing faith, their noble chivalry, their rude violence, have gone, and with them goes the most logical and enduring value. Their castles, cathedrals, and abbeys come down to our days, and preach to us stones the best of sermons. Truly it may be said of those great old monks that they laboured, and we have entered into their labours. The country elevated by the skill and writer alluded to, from Elijah and Elisha, is not inapposite. The rude vigour of primitive times gave way in the latter to winning arts and healing arts, and gentle words of social and peaceful intercourse.” The stream no longer bounds from rock to rock, but flows on in tame fields—in a channel, if less ruggedly beautiful, wider, and not so rugged, yet perhaps the same in dignity and grandeur. It is the same with regard to the arts. Our great works are few. Be it so; but do not these very vast and magnificent buildings of former ages tell another tale, viz., of labour unenumerated; of large populations pressed down by serfdom; of education little spread; of one order, and one order alone, that of the clergy, absorbing itself, not merely all that was spiritually good and great, but even all that comes under the term of temporal prosperity? Let us hope, then, that the work of architecture, if carried on by men of inferior genius to those who decorated the Parthenon, or raised to the skies our noble minstrels, may be practised in a spirit certainly of wider usefulness, and with aims not less beneficial.

INSTITUTION OF CIVIL ENGINEERS.

April 24th. The first Paper read was “On the Performance, Wear, and Cost of Maintenance of Rolling Stock.” By T. A. Rooker, Assoc. Inst. C.E.

This communication related to the statistics of three Prussian railways—the Cologne-Minden Railway, the Berghof-Maerkish, and the Rhenish—the general circumstances of which were stated to be somewhat similar. The tables embraced the particulars of the engines, and of the carriages and waggons, with the expense of repairs and renewals, the work done by the engines in 1884, the cost of motive power, the repairs and renewals of engine-tyres, and the commercial results. Also the experience of the wear of tyres on the Cologne-Minden Railway for the twenty years from 1865 to 1885 inclusive, embracing the results of observations upon about twenty-five thousand tyres, of different makes and of different materials.

It was stated that, in the Prussian railways, the iron-spoke wheels were gradually replaced by disc wheels, which, at first were of wood, but latterly they were entirely of iron. The first form of disc iron, adopted in 1845, was that of a bulged star; a wrought-iron plate, flanged for the periphery of the wheel, was inverted with five triangular lugs from the boss, which was cast on the plate forming the disc. This wheel had proved to be very durable, but it was noisy, and, the boss being 11 inches in diameter, the structure was heavy. It, however, supported the tyre evenly and well, and reference was made to a pair of these wheels with iron tyres, which had run 130,000 miles without requiring turning, and being still 11 inch thick, it was thought they would last up to 250,000 miles. In 1854, a pressed-wrought-iron disc wheel was introduced, the manufacture of which was both cheap and expedient. But it was felt that this iron necessitated a sound flange for the periphery of the wheel made it too rigid. Attention was then directed to the means of obtaining elasticity both in the form of the disc and in the material used. Accordingly, fibrous iron was employed, and the first, or disc iron, was corrugated, the depression being formed in a rim of fine-grain angle-iron, rivetted to the disc plate. Subsequently the disc and the rim were welded together, and about the same time the Bochum Company introduced steel castings, in the corrugated form, of combined iron and steel. In the important form of the corrugated wrought-iron disc, brought out in 1874, the iron used was highly fibrous. Several plates were forged to the shape of a double cardinal’s hat. This bloom was re-heated twice, and by frequent rolling was enlarged to 11½ inches in diameter. The rim was placed on the steam hammer, which, at the same time, punched the hole in the boss for the axle, and gave the form of the wave to the disc plate. After turning up the rim, the tyre was shrunk on and bolted. Since 1874, the tyre, whether of steel or of iron, had been welded on to the rim by hydraulic pressure. In this form, it was believed, the disc wheel offered the greatest amount of strength; the fibrous iron gave elasticity, the tyre was supported in every part, there were no joints, bolts, or rivets to wear loose, and after the tyre had been worn out, it was simply necessary to turn it down to the thickness of an ordinary wheel rim, and to shrink on another tyre. It was asserted that, with steel tyres, these wheels would run from 300,000 to 500,000 miles before requiring a new tyre; and that by grining the tyres instead of turning them their life would be prolonged from 30,000 to 60,000 miles.

The second Paper read was “On the Results of a series of Observations on the Flow of Water off the Ground, in the Woodburn district, near Carrickfergus, Ireland; with accurately recorded minute-pan gauge registrations in the same locality, for a period of twelve months ending 30th June, 1865.” By Robert Manning, M. Inst. C.E.

It was stated that the surface of the ground was chiefly composed of bare mountain pastures and grazing land, the surface rock being almost entirely tabular trap, overlying the chalk, with here and there patches of green sand. Three rain gauges were placed at the respective elevations of 300 feet, 750 feet, and 900 feet above the level of the sea; and two of these were emptied, one on the southern branch of the river, which received the drainage of 2076 acres, and the other on the northern branch 1329 acres. The stream gauges were rectangular notches with sharp edges, such as were used by Mr. Francis, at Lowell, and the water in calculating the discharge was that deduced from those well-known experiments. The observations were nearly eight hundred in number, and were recorded in an Appendix. From a summary of the results it appeared that the rainfall for the year was 35-867 inches, or
nearly 18 per cent. above that of Belfast. For the six months from November to May the rain was 147.68 inches, producing a flow of 14,351 inches, while from May to November those quantities were 21,101 inches and 7,357 inches. The minimum flow off 1000 acres occurred in March, and the Jurasseatic flow of 1829 was the maximum, in September, to 3180 cubic feet per minute; and the mean monthly flow was at its minimum in July, and was 29 cubic feet per minute.

The particulars of one year's rain having been thus ascertained, it was assumed that the rainfall on the Carrickfergus mountains bore a constant ratio to that at Queen's College, Belfast, where a daily register had been kept for fourteen years, and that it was the greater by 10 per cent. The result then arrived at were, that the maximum rainfall of 1829 was 47-71 inches, the mean for the fourteen years 1851-54 was 38.42 inches, and the average of the three dry years 1856-57 was 32.76 inches, and the minimum in 1855 was 28.8 inches.

The question then became, how much of this rainfall was available for water supply. Twenty or thirty years ago, the evaporation was taken as proportional to the rainfall, and was variously estimated at one-sixth, one-third, and two-thirds of the mean annual rain, according to circumstances. Now the balance of opinion seemed to be, that the amount of evaporation was not great; and, in selecting the most probable case, the following conclusions must be left to the experience and judgment of the engineer.

The author calculated that the loss, or the difference between the rainfall and the supply, which was the resultant fact of greatest importance, was due to the rate of evaporation of the surface, and to the state of the ground. He supposed that the sum of evaporation might be 18.28 inches, 132 days would be required; while for the mean, the 14.57 inches, 119 days would be sufficient. Diagrams were added showing the storage worked out for each month of the fourteen years, and for each of the three dry years. The state of the reservoir for a supply of 24 inches for eleven years, and 20 inches for the three dry years. It was remarked that, although the water in store attained its minimum in different years, that minimum invariably occurred in the third month of the year, and that, from the economical supply of water from the district under consideration, it would not be prudent to attempt to store a greater quantity of rain than about 10 per cent. over the average supply of the three dry years, provided there were no drouth or famine.

The question of water power was then incidentally alluded to; and it was remarked that in dealing with useless and injurious floods, and in providing a town supply, care should be taken not to incline to the destruction, by the breaking up of rocks, the whole country, and injuriously to interfere with the natural regime of rivers. The proportion of the mean annual flow of both branches of the Woodburn River, from a rain basin of 4750 acres, applicable to the supply of Woodlawn Mills, was then determined, and the calculations and results were given in detail. The tables showed, that the total flow off the ground, 21-71 inches, was lost on Sundays and by fires 12-22 inches, leaving 9-49 inches, or nearly 44 per cent., available for the supply of the wheel, which was equivalent to 194 days full work during the year, or 178 days on the average of the three years. The rate was reduced to 1-5 of the flow, it would work for 213 days, if 1-25 of the flow for 218 days, and if just equal to the flow, it would work 245 days.

May 8.—The paper read was "On the Water Supply of the City of Paris," by E. H. Biddle, M. Inst. C. E., and G. A. Switz, M. Inst. C. E., E. H. Biddle, the engineer-in-chief, as well as from numerous official documents. It appears subject to a supply furnished by the municipality of the enlarged city, in the year 1860, the population of Paris amounted to upwards of 1,600,000, and the quantity of water available from various sources was only 32,583,028 gallons per day, or rather more than 20 gallons per head per diem; but a large portion of this was used for municipal purposes, and nearly the whole of it was objectionable in quality. A careful study of the Paris basin, with a

view to ascertain its capacity for furnishing a water supply, as dependent upon the geological conditions of the district and upon its meteorology, that had been carried on since the year 1844, showed that the basin of the Seine was formed of a part of the granite upwelling of the Morvan, and the Jurasseatic deposits, without the intervention of the old and new red sandstones, or any trace of the carboniferous formation; the Jurasseatic, deposits being in their turn followed by the cretaceous formations, and the whole being covered with the tertiary strata around the French, which were attached great importance to the presence of the bi-carbonate of lime in water for drinking purposes; and that they held that a proportion of that salt, about sufficient to produce 16 of Dr. Clarke's scale of hardness, was necessary to prevent the French from the effects on the, and Belgrand gave the preference to the waters that filtered through the cretaceous formations that outcropped around the granite. The waters of the Dhuie and of the Sermillon were brought to Paris, from the plains of Champagne, by an aqueduct, along which they flowed by gravitation, reaching a height of 26 feet, and were conveyed. The authorities had also purchased the right to take a considerable quantity of water from the river Marne, at St. Maur, above its junction with the Seine; while the waters of the Somme Soude had been at Paris, from 450,000 to 700,000 gallons per day. It was however believed that the sources of operation would be in any case a matter to the city and lands surrounding these springs, the quantity from both these sources might be increased to 9,000,000 gallons per day, even during periods of prolonged drought. These streams after being united were led to Paris, and never left the city, and the water level at the quays was at times increased to 5 feet. It was carried on arches in such positions where the depression of the valleys did not exceed 33 feet, and where, greater, a cast-iron syphon, 3 ft. 4 in. or 3 ft. 8 in. in internal diameter, was necessary. The aqueduct was supplied by the impounding reservoirs, but in places the sides had a curvilinear batter, according to the nature of the strata traversed. Its inclination was as a rule very, but that of the syphons was made, in order to accelerate the discharge through the syphon, it was calculated to deliver 2,910,476 gallons per day, when running to within 1 foot of the crown of the arch, into the reservoirs lately built at Menilmontant, at a height of 301 feet above the level of the Seine. The materials employed in the execution of the Masonry were "piez metal" set in the cement of Vaas; the whole of the works being of this sandstone. The French had, by their interference with the flow from the roughness of the surface, and to prevent the infiltration of the land waters.

The quantity of water obtained from the river Marne, at St. Maur, was at Paris, from 450,000 to 700,000 gallons per day, and was conveyed to the future extension of the works.

The springs of the Dhuie had yielded, in the driest season of the last twenty-one years, 6,693,400 gallons per day, and those of the Sermillon from 450,000 to 700,000 gallons per day. It was however believed that the sources of operation would be in any case a matter of the city and lands surrounding these springs, the quantity from both these sources might be increased to 9,000,000 gallons per day, even during periods of prolonged drought. These streams after being united were led to Paris, and never left the city, and the water level at the quays was at times increased to 5 feet. It was carried on arches in such positions where the depression of the valleys did not exceed 33 feet, and where, greater, a cast-iron syphon, 3 ft. 4 in. or 3 ft. 8 in. in internal diameter, was necessary. The aqueduct was supplied by the impounding reservoirs, but in places the sides had a curvilinear batter, according to the nature of the strata traversed. Its inclination was as a rule very, but that of the syphons was made, in order to accelerate the discharge through the syphon, it was calculated to deliver 2,910,476 gallons per day, when running to within 1 foot of the crown of the arch, into the reservoirs lately built at Menilmontant, at a height of 301 feet above the level of the Seine. The materials employed in the execution of the Masonry were "piez metal" set in the cement of Vaas; the whole of the works being of this sandstone. The French had, by their interference with the flow from the roughness of the surface, and to prevent the infiltration of the land waters.

The quantity of water obtained from the river Marne, at St. Maur, was at Paris, from 450,000 to 700,000 gallons per day, and was conveyed to the future extension of the works. This was pumped into a second story of the reservoir of Menilmontant, at a height of 287 ft. 7 in. above the Seine. This water was tolerably pure and limpid, but it was rather hard, containing a considerable quantity of the carbonate of magnesia.

From the several sources which had been described, it was believed that a supply of 15 million gallons per day would be obtained in the course of the year, or the increase of the total supply of upwards of 47 million gallons per day for a population of 1,667,541.

On the left bank of the Seine there had recently been purchased a series of springs rising from the chalk formation, at Armenieres, in the department of Oise, near the town of Chantilly, Champs, and the Chateau of St. Philbert, Montlhery, Theil, Noce, &c. These waters would be led to Paris by an aqueduct 104 miles in length, and it was calculated that the quantity that would be so delivered would be equal to 22,325,000 gallons per day. When all the works for improving water supply were completed, including the supply derived from the Marne, the Canal de l'Ore and its increase, the Artois wells about to be sunk in various parts of the city, &c., it was estimated that there would be a gross total of 180 million gallons per day, which would be much larger in quantity than that of Paris was likely to become. But it must be borne in mind that the waters of the Canal de l'Ore would still constitute more than one-half of the whole quantity, and as soon as the canal was navigable it was exposed to various sources of impurity. In future years, to a certain extent, it might not be necessary to take from the Dhuie, the Marne, and the Seine, the other to supply the waters of the Ore and the Seine for the service of the street washing, for the monumental fountains, and for other purposes of municipality. If the works taken from the Dhuie, Marne, and the Seine, the other to supply the waters of the Ore and the Seine for the service of the street washing, for the monumental fountains, and for other purposes of municipality. If the works taken from the Dhuie, Marne, and the Seine, the other to supply the waters of the Ore and the Seine for the service of the street washing, for the monumental fountains, and for other purposes of municipality. If the works taken from the Dhuie, Marne, and the Seine, the other to supply the waters of the Ore and the Seine for the service of the street washing, for the monumental fountains, and for other purposes of municipality.
of Belleville, lately constructed, were intended to receive the waters of the Dhuys and of the Marne; and they were calculated to convey together, in the two stories of arches of which they were composed, about 294 million gallons. The cubical contents of the existing reservoirs, without including that of the Basin de la Villette, at the extremity of the Canal de l'Ouse, amounted to nearly 23 million gallons. A description was then given of the reservoirs at Passy and Molitor, and with regard to the former it was remarked, that all the skill and attention of the French engineers had been employed in vain, in the attempt to prevent the action of atmospheric causes upon the masonry, which had given occasion only for an increased estimation for the maintenance of the masonry. It might be that the perfection of the setting of the cement upon the masonry had something to do with this effect, for it could not yield, like an elastic substance, such as mortar of the proper quality of hydraulic lime. In the construction of the reservoir at Molitor, a mixture of Portland and common or flint sand marl, which were hard when originally cut, but which yielded under the influence of the atmosphere, had been "rendered" with a coating of plaster of Paris 1 inch or 2 inches in thickness. This had been found to be an efficient temporary protection from disintegration under the effects of rain and of frost.

The appliances for securing the efficient distribution of the water brought into Paris, and the quantities required for the different services, were then detailed; and it was stated that the authorities undertook to deliver, when all the works were completed, gratuitously to the citizens a total quantity of 54 million gallons per day. The execution of the works required the distribution of the water to private houses and factories, or any undertaking by a company, under an agreement with the town, for fifty years, during which time it was to collect the water rates, and at the expiration of that period, the whole of the estate was to become the property of the city. The profit arising from the expenditure, as a fixed schedule of prices, and the sum to be annually paid upon as a remuneration for the risk and trouble undertaken by the company, were the first charges upon the revenue, and the excess beyond these amounts was shared in the proportion of 75 per cent. to the town and the company. In the year 1858 it had been estimated, by M. Belgrand, that during the year 1858, 17 million gallons of water had been delivered. The receipts for the private supply in 1858 amounted to 3,832,760 francs from 23,074 subscribers, a number which, it was calculated, would be increased by 2000 in twelve months. Considerably above the upwards of 25 millions of the rate of the revenue might be cited as a proof, if such were wanted, of the bad effects that must always attend the gratuitous supply of water upon the habits of daily life of the citizens. It might be added, that the price charged to the water-carriers at the Elligeri fountains was nine centimes for 280 gallons, and this quantity was retained for four shillings. This increase in the price was one of the principal reasons brought forward to justify the great outcry incurred in leading to Paris the spring water from the Dhuys and the Vanee.

In conclusion, the author thought, upon a review of all the conditions of the Paris water supply, that it must be regarded as a commercial failure; for while the town paid 2,000,000 francs for salaries and repairs, it derived 2,000,000 francs from 23,074 subscribers, a number which, it was calculated, would be increased by 2000 in twelve months. The whole was a matter of consideration, that the water-carriers were never asked the reason of the high price, and it was only when they were asked why the price of water was so high, that they replied, "We pay to the city 25 millions;" that the system of water-carriers was nine centimes for 280 gallons, and this quantity was retained for four shillings. This increase in the price was one of the principal reasons brought forward to justify the great outcry incurred in leading to Paris the spring water from the Dhuys and the Vanee.

COMPETITIONS, THEIR PRESENT BEARING ON THE ARCHITECTURAL PROFESSION AND THE PUBLIC, AND WHAT THEY SHOULD BE.*

By John Linton.

In treating of the present subject I feel I am treading on what some people would call dangerous ground; and, therefore, ere I begin it all I am to exculpate myself, by assuring our readers, who may in any case come across this paper, to believe me to be perfectly sincere when I say I am in no way actuated by personal or petty motives, and in penning the following lines individual prejudice and spite are absent from my thoughts. The matter I wish to deal with is one in which I feel our profession as a body requires and demands reform. At Passy on this Montsouris, I have proposed to take it up, in hopes that I may draw from this Institute an expression of opinion, followed by action so united and decided as may show to the public at large and the profession elsewhere, that, though Irishmen, we can do something to grapple with what we believe to be an evil, even though that evil be great, and have a strong hold upon the public.

To begin a paper on such a subject as the present one, I should, perhaps, first treat of "Competitions" as a whole, and then proceed to deal with the pros and cons incident to my subject; but I should be only wasting time and insulting your common sense if I were to linger over mere definitions. I accordingly pass on to the present and cannot beg leave to indulge in any treat of competitions as they are, and what they should be, according to my own ideas of the subject only, and I throw out my remarks to provoke discussion, and leave the verification of them in your hands. Competition, I cannot but think, as it is at present, is a great and grievous aliment under which we suffer—not quite so much as we may say as the days are, which, for one reason, I take to be, for I sincerely believe the cure of our disease lies in our own hands; so I must beg of you to be more than patient with me while I urge on you the great magnitude of the question.

The great points in favour of competition, so far as I have been able to glean them, are—the benefit to be derived by the profession from the field open to all, and the necessity that this gives for the elder and recognised practitioner to keep himself up to the mark, and even with the times; and there can be no question but that these two points are most essential, and would be productive of the greatest benefit to the profession and public, if competitions were gone out fairly and honestly on all points.

You may take it that I invent nothing in this paper. I am writing about the profession and the public together, and I do so advisedly, for I cannot but feel that the interests of one and both are identical, so far as they relate to matters of competition.

The pros thus easily and quickly disposed of—for I think we must all acknowledge the truth of them all—of their numerous, and their necessary, and their need of the competition principle, and having the crowning of our success lies, our "judges." You must understand me that I am speaking of the system generally, and not in my mind any thought of individual competitions, competitors, or judges. On this last word "judges" I pause, for I feel that under this head will be found the most vital of the lists in the competition articles.

As professional men, are we not led to believe—nay, is it not forced on us—that it is our duty to lead the public mind on such points as these, what are true principles in art? what is in true taste, and what is not?—else, where is the use of our expensive special education, of our long stay given to the study of applied studies, of our knowledge of truth and mathematics in architectural art? I ask you, do we do so under the present system of competition? and I know your answer must be, "we cannot;" and wherefore?—because naturally it is success over our fellow professionals, whose judgment is to decide the winner in whose hands the crowning of our success lies, our "judges." After you would ask "the public" to say if, as a general rule, our "judges" are the right men in the right place? My answer is, no. And it is really expecting more than human nature is capable of to suppose that they can be. How are they educated to fill such a post? do they lay themselves out to gain such a knowledge on the subject as would warrant them in undertaking to adjudicate? does a mere scattering of art make them masters of their position? or does it not on the other hand make them all the more dangerous, as liable, from their much talking, to mislead others? Which of us has not come across that tutor of our profession whom any man who considers he knows everything and can do everything, and therefore, when he tries it on, spoils everything? Such a man is often to be met on competition committees; and were to the committee who has such a one for its guide to architectural knowledge. It would be far better for us to have it had in itself the elements of all discord and all abuses; for at what will the amateur stop at nothing, no matter how underhand or discreditable, to carry his point, and show his supposed knowledge. But this, you will say, is after all but natural; granted it is; but is it, therefore, fair play to us? I might go on, and mention the cases and show up the competition of our committees of "judges," but for...
my present purpose it is enough that we should agree on the point that they are not as they should be; therefore be it our duty to aid them, and if they do not avail themselves of our advice, they are to blame. I now come to competitors, and under that head we all, in a great measure, stand. Gentlemen, I must be fair in my remarks. Many of the competitors in the several cases have been mild and humble, but we can never hope to surmount those obstacles; but we may shame them into a change for the better, I take it, and in more ways than one. A friend said to me the other evening, hearing I was about to read this paper, "Competition, to our profession, meant, Who has the most friends." This, I add, for, in my case, it is not a true one; and of course we must not go further unless the object of our profession is not to make a difference in any graver charges made against members of our profession? of base and low tricking being resorted to for the purpose of ensnaring success? Gentlemen, this disgraceful system of favoritism and incompetence on the part of our judges, and of dolging on the part of our clients, is for the interest of the public, utterly wanting; of our duties on the part of both judges and competitors, a damming effect on competitions, and a demeaning and degrading effect on the tone of the profession, and on the mind of the public.

This is but a faint outline of some of the evils of the system of present-day competitions, and with these remarks I close competitions as they are, and proceed to what they should be; though under this division I will also treat of many existing evils, but more especially in regard to their cure. First come in, all their majesty, our "judges;" and under this head an inherent difficulty presents itself in their election, for after all our judgment of persons of unimpeachable integrity, they are rarely, if ever, chosen as men competent from having had their attention previously directed to the requirements of the necessary knowledge which would enable them rightly to adjudicate on, much less to understand, the points and beauties of the plans submitted to them; indeed, in most cases, the "judges" are as a host of flies; they begin, and in answer, not knowing what they want, how they can they attempt to decide, or say which plan is what is wanted or which the best. To meet this difficulty, I would propose that in each competition our judges should avail themselves of the services of an architect, who would be neutral in the competition, and whose function it would be, regardless of our judges, and persons of unimpeachable integrity, to lay before them the plans submitted to them; and then, when the plans are submitted, carefully to go over, and read them with him, and explain to the committee, the "ins and outs" of the various plans. As I take it, it is quite impossible for any one, without a large amount of experience, to read a plan, or follow out arrangements and economy of space, combined with convenience, beauty, suitability and stability. In the foregoing passage I have spoken altogether of "plans," and I feel very confident that if in competitions plans were all that were sought for in the first instance, the arrangements would be more satisfactory than at present. So may appear, as I think we may take it for granted that the man who can make a good plan can make a good elevation; but even supposing such was not the case, and that it did not follow, then let there be either a second competition for an elevation to the accepted plan, or let the consulting architect be employed to carry out the plans. The above view of the above is quite upon me, and we would quite upset that abominable and unfair system of choosing a design in consequence of its elevation being pretty or of a particular style, which, when it is about to be carried into execution, from its excessive cost has to be stripped of every thing which in the first place recommended it, and the attention to the most essential and noble points. I am a monument of a flagrant injustice to other competitors, who honestly "cut their costs according to their cloth." Our judges should further remember that the agreement by architects to compete on the certain terms laid down, if acted up to by the architects, becomes a mutual contract, which is morally, and I even believe, legally binding on our "judges," and I would go so far as to say that, in not carrying out the terms of their agreement to the letter, our judges in many cases leave themselves open to actions at law. As an institute I think we should be very glad to give assistance to the business of the public, and to do such things as will be of great good, in cases when other professional knowledge would be of use, that the services of members of other professions should also be called into requisition, and for this purpose—that the instructions as to what is required should be as clear and concise as possible, but at the same time in no way confining or restricting architects to any particular arrangement, except where the same is necessary, and then it cannot be too distinctly stated; if rooms of a certain shape or size are desirable or necessary, this should be specified; as also if there be a preference for, or a leaning to, any particular style. We all know that in many cases the "judges" view their possibilities, and are very capable of any suggestions that may be made to them in their, at all times, if fairly and honestly carried out, most arduous task; who are, therefore, so fit to make these suggestions as the members of our profession, or who have a better right or should more thoroughly understand the subject? Therefore, as I feel it is the duty of the institution to do such work, I submit for your consideration whether it is not most desirable that we should now take some steps for the better regulation of competitions; and, as a stepping-stone in the right direction, I shall submit to this meeting a few heads to be discussed, that, when whipped into shape and worked out in detail, may form the basis for future regulations for competitions. I submit that our "judges," I will give them a hint, by the way, that although they cannot premiate all the designs submitted, good manners might suggest to them sometimes the propriety of at least thanking the unsuccessful competitors for their trouble, expense and loss of time.

1. Inasmuch as it is absurd of our "judges" to state the amount of accommodation required, and then to say it must be done for such a sum—in other words, insisting upon having a quart and paying for a pint—it is desirable, if they specify the accommodation, they should give only an approximate idea of the cost. I consider the following plan of working for future competitions is as follows: Before doing so, however, and leaving our "judges," I will give them a hint, by the way, that although they cannot premiate all the designs submitted, good manners might suggest to them sometimes the propriety of at least thanking the unsuccessful competitors for their trouble, expense and loss of time.

2. In cases where the outlay is distinctly stated, inasmuch as it is most difficult to come to a true decision as to the cost of the building, it is essential that the standard of remuneration required by our "judges," so as to be clearly understood by those about to compete; and then, when the plans are submitted, carefully to go over, and read them with him, and explain to the committee, the "ins and outs" of the various plans. As I take it, it is quite impossible for any one, without a large amount of experience, to read a plan, or follow out arrangements and economy of space, combined with convenience, beauty, suitability and stability. In the foregoing passage I have spoken altogether of "plans," and I feel very confident that if in competitions plans were all that were sought for in the first instance, the arrangements would be more satisfactory than at present. So may appear, as I think we may take it for granted that the man who can make a good plan can make a good elevation; but even supposing such was not the case, and that it did not follow, then let there be either a second competition for an elevation to the accepted plan, or let the consulting architect be employed to carry out the plans. The above view of the above is quite upon me, and we would quite upset that abominable and unfair system of choosing a design in consequence of its elevation being pretty or of a particular style, which, when it is about to be carried into execution, from its excessive cost has to be stripped of every thing which in the first place recommended it, and the attention to the most essential and noble points. I am a monument of a flagrant injustice to other competitors, who honestly "cut their costs according to their cloth." Our judges should further remember that the agreement by architects to compete on the certain terms laid down, if acted up to by the architects, becomes.

ON GRANITE WORKING.*

By George W. Muir.

It is not my intention to attempt a scientific account of the origin, composition, and geological place of granite. It is intended chiefly to exhibit granite as it is in the rough, show what can be done with it by art, and state how and where it may be procured.

* Read to the Society of Arts.
The districts in Scotland from which granite is chiefly obtained are Aberdeen, Argyllshire, Dumfriesshire, and the stewartry of Kirkcudbright. In Aberdeen, Argyllshire and Kirkcudbright, the granite is red and variegated. But in the south of Scotland the grey only, and that generally of a very light shade.

Although Aberdeen has acquired the reputation of being the source of the granite now so much used for architectural and monumental purposes, very little of the finer qualities can be had there. Out of all the provinces near Peterhead, from which the granites worked in Aberdeen are chiefly obtained are situated at distances varying from thirty to fifty miles to the north and west.

The red-coloured granite is quarried at Peterhead, 40 miles by rail to the north of Aberdeen, and the finest of the blue grey at Cullen, seven miles south of Peterhead. A very fine black grey has also been found near Alford, on the line of rail from Aberdeen to that town. The old quarry of Rubiallaw, near to Aberdeen, and from which the stone used in building one-half of the city has been obtained, supplies a granite which, when polished, exhibits a fine dark blue colour and well-marked graining. It has hitherto been a favour of the light colour, but of late the quarry has been in a condition unsuitable for the production of pieces of a large size.

The granites of Argyllshire, and especially the red and pink varieties from the island of Mull, are becoming favourites for all purposes. This is probably on account of the independence of the material, the textures and the very well marked grain. The latter being a short piece of steel inserted in a hole in the stone between two thin pieces of iron. By striking the plug with a heavy hammer the stone is split into pieces of the size desired. At the Kirkmabreck quarries no powder is ever used, but the stone lies in the most favourable position for detaching. It is dry-coloured, and is as little powdered as possible, and the rock is frequently shattered in a way not intended, but it is not possible in every quarry to dispense entirely with its use.

No material is to be compared with granite for ornamental purposes. Besides the beauty of the stone, it possesses the great recommendation of durability. Of what service is a monument of free standing, the inscription worn off by the sun of the lifetime of those by whom it has been erected, and perish just at the time when it was expected to inform succeeding generation of the virtues of the person whose memory it was intended to perpetuate! We frequently are employed to renew, in granite, tablets of freestone that have been fixed in church and court-yard walls, and which, for beauty and durability, no longer serve the object for which they were originally designed.

Granite is now being very largely used for ornamental purposes in buildings, and I do not doubt that its use will very greatly increase, and that it will come to be used with greater skill and discernment than it now is. The sense of colour of, say, thirty, forty, or more columns on the front of a bank or other building, when all are of one colour, is not pleasing. Would it not be better to employ a variety of colours, or a variety of shades of the same colour.

Take any of the colours of the specimens now before you on the table. Let it be the dull, flesh-coloured red of Peterhead, or the livelier hues of Tornour from Mull; the light grey from Kirkmabreck, or the dark from Rubiallaw; or even the unique and delicate pink from the north Bay of Mull, and it is impossible to come to any other conclusion than this, that the front of any building constructed wholly of any one of these colours will not be so beautiful as it would be if their varied colours had been judiciously combined. Great variety and beauty may be produced also by varying the style of work. Let the base be rough rock, the first courses above rustic, the next single-axed, and the highest fine-axed, and let their dull, solid surfaces be varied by pilasters, lintels, and string-courses, and a building worthy of the greatest name in architecture, or the most honourable purposes to which any building can be applied, would be the result.

In selecting granite it is advisable to consider the purpose to which it has to be applied. The stone best suited for a monument or building in a position from which it can be closely inspected, may be of a finer grain than if it has to be placed at a higher elevation. I have seen buildings with very fine columns of grey granite, so small in the grain, that at the distance from which they could be seen the effect was no better than if they had been so many cylinders of zinc.

A part from all commercial considerations, which may be suspected to influence one engaged in the granite trade, I should

Shilling per ton, ten shillings per cube foot, or one hundred and forty times the price of rubble, is cheerfully paid for a finer kind.
like to see granite used for the external front walls of buildings. Which company will be the first to have an office of which the front shall be wholly of polished granite? The cost would not be so great as may be supposed. The more extensively granite is employed the cheaper can it be supplied.

Granite may also with advantage be more largely used for interiors. A polished granite stair and staircase would be a very beautiful thing, and granite columns form a beautiful feature in a hall or corridor. By the combination of various colours a composition of great beauty can be produced.

It may be observed that the manner in which the stone is changed from the rough to the smooth-polished surface. The form is given to the stone by the hands of skilled masons, in much the same way as is done with other stones of a softer nature. Of course the time required is considerably greater for the case of granite as compared with other stones. If the surface is not to be polished, but only flueaxed, as it is called, that is done by the use of a hammer composed of a number of slips of steel about a sixteenth of an inch thick, which are tightly bound together, the edges being placed on the same plane. With this tool the workman smooths the surface of the stone by a series of taps or blows, given at a right angle to the surface operated upon. By this means the marks of the single axe, by which the blows are given obliquely on the surface of the stone, are obliterated, and a smooth face produced.

Polishing is performed by rubbing, in the first place with an iron tool, and with sand and water. Emery is next applied, then putty wax, and finally polished with the finest of muslin. This work is best performed by machinery, but all carvings, or surfaces broken into small portions of various elevations, are done by the hands of the patient hand polisher. The operation of sawing a block of granite into slabs for panels, tables, or chimney-pieces, is a very slow work, and the rate of progress being about half an inch per day of ten hours.

The machines employed are few and simple. They are technically called lathes, waggons, and pendulums or rubbers. The lathes are employed for the polishing of columns, the wagons for flat surfaces, and the pendulums for mouldings and such flat work as is done for the same purpose. In the first case, the column is placed, and supported at each end by points, upon which it revolves. On the upper surface of the column there are laid pieces of iron, segments of the circumference of the column. The weight of these pieces of iron lying upon the column, and the constant supply by the lathe attendant of sand and water, emery, or putty wax, or whatever is required, will polish the whole column which has been brought, constitute the whole operation. While sand is used during the rougher stage of the process these irons are bare, but when using emery and putty, the surface of the iron next to the stone is covered with thick flannel.

The wagons are guided upon rails, in which the pieces of stone to be polished are fixed, having uppermost the surface to be operated on. Above this surface there are shafts placed perpendicularly, on the lower end of which are fixed rings of iron. These rings rest upon the stone, and when the shaft revolves these rings rub the surface of the stone. At the same time the waggon travels backward and forward upon the rails, so as to expose the whole surface of the stone to the action of the ring.

The pendulums are a frame hung upon hinges from the roof of the workshop. To this frame are attached iron rods, moving in a horizontal direction. In the line upon which these rods move, and under the frame is the floor. Pieces of iron are then loosely attached to the rods, and allowed to rest upon the surface of the stone. While the whole is set in motion, these irons are dragged backwards and forwards over the surface of the stone, and so it is polished. When polishing plain surfaces, such as the needle of an obelisk, the pieces of iron are of course flat, but when we have to polish a moulding we make an exact pattern of its form, and have the irons cast from that pattern.

I have thus described the established modes of working granite. A Frenchman has lately introduced machinery by which he processes to polish granite with much the same method as is used by mechanical engineers for the cutting and polishing of iron; but as yet, so far as is known to me, this new apparatus has not been found effective.

The demand for polished granite comes from all parts of the world. It is sent to every British colony, and to many parts of the continent of Europe.

To show the rise and present extent of the polished granite trade, one fact will be enough: thirty years since, the late Mr. Macdonald had but four men in his employment, now his successors employ fifty times that number. I will not boast of the progress of the Scottish Granite Company, but we began a year since with an engine of six-horse power, and I hope soon to start another of thirty-horse. I can also say that we are now engaged in polishing the heaviest columns ever made in Scotland. They will weigh about forty tons each, and I hope you will all live to see them on the new bridge at Blackfriars.

The columns are constantly obliged to make in sections. This has arisen, not from the quarries failing to produce blocks of sufficient size, or our machinery being unable to handle them, but from the difficulty and risk of the transport from the polishing works to their intended position on the piers of the new bridge.

Now that the granites of the west of Scotland are becoming known and estimated at their proper value, and that Glasgow, the commercial metropolis of Scotland, with all the advantage of ready communication by sea and land, has entered into competition with Aberdeen in a line of business hitherto considered peculiar to the "granite city," the art of working granite will receive an impetus greater than any yet given, and this beautiful and most durable of materials will be applied to purposes for which it has not yet been considered suitable.

In the discussion on the foregoing paper, Mr. Botley, in reference to the beautiful effects alluded to of polished granite of different colours for the pavement of entrance halls of private residences, inquired what would be the cost of so paving a hall, say 10 feet wide and 20 feet long.

Mr. Muir replied, that would be a superficial area of 200 feet, and would cost from £120 to £130, or about 12s. 6d. per square foot. That would include slabs of various colours. A portion of the floor of Norwich Cathedral had been paved with polished granite, and the effect was very striking. The thickness of the granite made at the expense, which would be the same whether the slabs were two inches thick or one foot; the cost being not so much in the material itself as in the cutting and polishing. The most practical thickness for pavement was one inch. With regard to the alleged difficulty in the transport of large blocks, he might mention that the Scottish Granite Company had furnished four blocks for the Albert Memorial in Hyde-park, weighing 60 tons each. On the subject of accidents from blasting in the quarries, they were not unfrequent, but for the most part they arose from want of due care on the part of the workmen themselves and a disregard of danger, which was engendered by habit, much the same as in coal mines.

Mr. Muir gathered from the paper that the working of granite was essentially a manual process, and that labour-saving machinery had not been nor was capable of being introduced to any great extent into this operation. [Mr. Muir said, except for polishing.] He believed some twenty years ago machinery for cutting granite was proposed by a man named Hunter, with the view of saving labour in the primary operations, and he had hoped to have heard this evening whether any practical results had attended that attempt.

Mr. Muir replied that all the machinery yet invented for that purpose had failed.

Mr. Bissnor regretted to hear that the granite columns for the new bridge at Blackfriars were intended to be made in sections. He had hoped that, in that instance, an opportunity would have been afforded of erecting monoliths which would bear comparison, to some extent, with those which were met with amongst the ancient remains of eastern grandeur. No doubt the practical difficulty in the way of monoliths was the great expense of transport. There were many large monoliths which had been met with in the ancient remains amongst which the obelisk of Heliopolis was remarkable. That was supposed to have been floated down the Nile. He had also noticed some very large blocks of granite in the ruins of Baalbec. There were in particular three blocks in the Propylaeum placed clear of each other, 124 feet each, which were about 64 feet long and 12 to 14 feet thick. We had nothing in this country to compare with these, and they must necessarily have been transported by land carriage. The quarry from which those blocks were obtained was situated two miles from Baalbec, and there still remained there a similar block, almost ready for transport. The weight of this block was, of course, enormous, and it was lying some 12 or 14 feet below the surface of the surrounding country; but, if it had been transported, an almost insuperable difficulty would have been found in the transport. But those blocks in the temple had been elevated 20 feet in the wall; if, therefore, the ancients were able to accomplish such a feat, with their rude mechanical appliances, there ought to be no difficulty in the management of monoliths in the present day.

Mr. Muir remarked that the difficulty of transport was solely of a
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

June 1, 1866

Financial nature, and this was the most troublesome one to be got over. It was proposed to bring from the Mill quarry a block, estimated at 700 tons, for the parapet. The cost of transporting this block was estimated to be £10, and he believed it to be solid to a depth of 15 feet; but the main difficulty of transporting it to London consisted in the very great expense this would involve. It had even been suggested to take it to America, for a memorial to Abraham Lincoln. Mr. Tennant had been asked for a parapet of these stones, but he had not been allowed as supplied for the Albert Memorial, the cost of the crane alone for lifting them was about £650, and the whole mechanical arrangements were provided at a total cost of about £1500. Therefore, unless the contractors were willing to advance orders for these large blocks, they could not be supplied, except at a very high cost.

Mr. Strahan said, in reference to the more general application of granite for building purposes, it would be satisfactory to hear from Mr. Tennant what was the cost of the Albert Memorial, the cost of the materials, and he believed it would have been a very costly affair to have carried out the idea of the Houses of Parliament in polished granite. He would be glad to hear what was the expense of dressed granite for a parapet, as compared with other descriptions of stone.

Mr. Birley would add to that inquiry, whether the polishing rendered the granite less susceptible to atmospheric influence than when the work was rough. It had been found that Portland stone and Irish granite in Salisbury Cathedral, which had been subject to scaling, was considerably reduced in this degree to which they were polished.

Mr. Munt said that the result of twenty years' experience with polished stone was that a piece which was a very short time in connection with such a material as stone, in Portland stone in particular, after it had been polished, a certain amount of rust had taken place in that time, and that the polished stone had been less rusted, but nothing to which the word "rusting" could be applied had taken place. The polished stone has in the Mill, but there was rusted in the Mill, was the result of the air and the stones, he believed, from an excess of alkali in the granite, for when that was present beyond a certain amount, decomposition went on very rapidly. In the different granites there were two kinds of felspar: in fact, they were doubtless the most durable of all materials, but he was afraid the white granite, and soda felspar in the red, with quartz and mica in addition. In the Scotch granite, and in that from Dartmoor, they had a form of tourmaline, which made it extremely brittle, and if it was exposed to the wind it was more likely to be exposed to the wind than any other class of stone. The Chairman stated that there was great interest connected with the working of a material which had been supposed to be the earliest formation of which this world was composed; and when properly selected it was doubtless the most durable, and of all materials, it was the worst trial that the cost would preclude any very general use of it on the streets of London, until cheaper modes of manipulation, by machinery or otherwise, were discovered. With regard to the natural decay of this stone, it was necessary to say one word after the able remarks on that subject which had been made by Professor Tennant, but all travellers in Switzerland must have noticed the very rapid decomposition of the granite which went on, especially in the district of Chamounix. There could be no doubt that an enormous quantity of granite was used for upper granite formations by the action of the weather; but the surface over which this action took place was so large, that the extent of decay at any one point was very slight indeed. The light-coloured earthy uncles that were brought down by the Asa and other rivers were covered with masses of broken granite, and the whole of these fragments were used for building purposes, as compared with other descriptions of stone. Looking to the Houses of Parliament, he thought if the expense of facing that great structure had been double what it was, it might very possibly have been true economy; for that vast expenditure seemed likely to be wasted, inasmuch as the ornamental work was rapidly decaying. It was a melancholy fact that the material of many of our modern buildings was crumbling away even during the lives of those who had constructed them. Another interesting point was with reference to the stonework. No doubt the theory of Professor Tennant on this subject was correct. If the stonework was not to be removed by the after process of polishing, the effect would be apparent upon the consequences that time would have upon the material. He believed that Aberdeen had been referred to as the "granite city." It might have merit in the solidity of its granite houses, but it had the demerit of great monotony and coldness of colour, and the hardness of the material was such that there was not only monotony of colour but absence of ornamentation; so that, whatever other merits granite might possess, it would be safe to claim the promotion of florid ornament in architecture.

ARCHITECTURAL ASSOCIATION.

The annual business meeting of this society was held on the 4th of last month, Mr. R. W. Edis, President, in the chair. The alterations of Rules 4 and 6, of which notice had been given as mentioned in our last, were carried. The amendment on the
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

the proposed alteration of Rule 5 was lost on division. In considering the annual report of the Architectural Alliance, the paper by Mr. Hine of Nottingham, setting forth the propriety of making, the bills of quantities a part of the basis of contract in building works, was read by the Secretary, after which the Chairman requested Mr. Richman to give his opinions thereon. Mr. Richman said that this subject had been brought forward by Mr. Hine, who was a man of very large experience. The subject matter of his paper was increasing in importance to the profession, as standing between clients and builders. The position of the measurer was also becoming every day more and more important, because architects and contractors are now engaged in large practice not the thorough business, if their business is of any extent, is as much higher than it was. The builders of the last day were men of greater knowledge than those with whom architects had to deal years ago. The number of architects who looked solely at the interests of their clients, without also looking at what was due to the builder, was increasing. It thus became of greater importance, for the satisfactory settlement of every building contract, to have all matters of detail clearly stated so that the sum of the contract was known, and not merely the items of the contract. Throughout the country the custom of making the quantities the basis of the contract was coming more and more into use, so much so that with many clients of experience in building, they would not allow an architect to carry out works for them unless he himself provided the quantities, so that it might be known to what extent the quantities of the drawings were correct and that the quantities were based upon them. Supposing a contractor undertook to do certain work on the representation of the bill of quantities, he was not bound to do more work than he was enumerated in that bill of quantities. The reason that questions relating to works to be executed, had been so often referred, was the result to a great extent of the lax manner in which working drawings and specifications are got up at the present time. Specifications here and there went into minute particulars, intimate work sometimes of a very expensive character, while other portions were not so minutely, if at all, referenced to the drawings. He would advise the architect to have his drawings and specifications got up in a business way, and not merely in a quasi artistic manner. Mr. Richman concluded by expressing the hope that the necessity of including bills of quantities in the contract would be urged most strongly upon the profession through the Alliance.

Mr. F. Wilson, in a paper read with views upon the subject which were very far from defined. A good many of the arguments which had been used might be summed up by this, that there was a great deal of imperfection in the manner in which some architects prepared their documents; while those prepared by surveyors were supposed to be more accurate, and therefore it was desirable that they should be specified in detail. At other places construction and important features were neglected or ignored, and their details were required by the architect to be executed totally at variance with what any man of standing would expect, when compared the original drawings. These were things which occurred day after day, and were proofs of the lax manner in which architects executed tasks, and guided many professional men at the present time. In many cases the quantities that were prepared by the surveyor for work proposed to be executed were considerably in excess of what appeared from the drawings and specifications. This was due to the difficulty of arriving at the desired results. The drawings and specifications were utterly inefficient, the architect would still persist in introducing a great variety of work into the building which had not been originally mentioned. This may be seldom done with wrong intention on the part of the architects, but they have come to think too exclusively of their clients' interest. It was quite true that the surveyor did leave a margin, but from experience he was of opinion that this margin arose not from taking work too fully (for a surveyor would take work more closely than a builder dared to take it), but from the fact that the original documents placed before him were insufficiency for the purpose, and there were architects who were unwilling to have their plans completed. Consequently errors of omission appear in the quantities, some work must be omitted from the contract, in order to make up for the deficiencies which had been found. That was not precisely a loss on the part of the client, because he must not expect to get more than he pays for. But it was a loss to the contractor who had gone through all the respectable contractors, but no man who had once carried out a considerable work for them would do so again, unless a clause was introduced that quantities should form part of the contract. That is to say, that the measure of what the builder had to do should be the very schedule of works on which the builder originally con-
in throwing blame on any part of the profession, yet it would be
found that bills of quantities were not always faultless. If bills
of quantities were not exact, it would be, that the bill of quantities
would be brought up against the architect and his client's interests, under all circumstances where
anything was omitted; but if there was a surplusage nothing
would be said, and it would go into the builder's pocket, and the
client would get no benefit at the public cost. Under such unsatis-
factory condition, the problem of trying another scheme altogether, such
as that of priced schedules, as used largely by the Government.
However experienced and well-intending a surveyor may be,
there would always be a margin, either too much or too little, at
which he could not arrive. A better plan was to get a good
quantity surveyor, and have him carried on by the architect himself.
By this means the difficulties of alterations and extras would be
avoided, and the architect, builder, and client would arrive at a truer
understanding of their relative positions than by any other
possible means. If they could be sure that all men employed on
the building were neither rogues nor fools, the simplest and
perhaps the best system would be that of day-work under a good
clerk of works. But as they could not always ensure honesty
and common sense they must adopt some other plan: architects
ought not to give up their position and authority in the matter
under discussion. He was a conservative, and should prefer things
remaining as they were not to be changed in the system, and to
discuss Mr. Hine's paper in detail, but if they were to take it
to clause by clause, he was sure that the result at which they
would arrive was, that the adoption of the system recommended
would be injudicious and unwise.

Mr. BLASHILL said that some years ago he had been a member
of the board of the Hill Park Company, and he had to
be discussed under consideration, and a point which occurred to him at
that time had been forgotten in the present discussion. Mr. Christian
had said that taking out the quantities was work done for the
builder. In the olden time there was not only competition as
to prices, but also as to the skill of the builders in taking
quantities with closeness to the drawings. By the present
system that guarantee was lost altogether. The only competition
now was as to prices, and quantities were matters about which
the architect could not be sure at all. There might be con-
derably more or less work than appeared in the quantities,
but at all events the builder must do the work, and the client
pay the contract price, without any real remedy for excess
or deficiency. If any alteration were made, it might be worth
considering whether the contract should not be based upon
the quantities alone. For the quantity and quality of the labour
and materials, as there were the only matters of importance for the contractor, the design
and arrangement of these materials are chiefly of importance
as between the architect and his client, and they would be
shown by the drawings and specifications, which under such a
system would show the builder how and where to place the
work he had contracted to do. The objections to this system
would be the expense of the extra drawings and omissions,
and the uncertainty as to the ultimate cost, but from these very grave objections the present system
was not wholly free. To make the quantities a part of the contract,
retaining the other documents, would tend to produce disputes
by increasing the chance of discrepancy.

Mr. R. O. HARRIS said, in making bills of quantities part of the
contract, the whole of the surveyor's responsibility was at
once thrown upon the architect or his client, who had to depend
upon the ability of the surveyor employed, a liability which few
architects would care to accept. He did not think that architects
ought to be expected to do anything—consultants, they were expected to do everything—
could be expected to take out bills of quantities with the precision and
accuracy modern builders require for a large building. The
state of affairs had better remain as at present. It frequently
happened, that all a surveyor had to guide him in taking
quantities was a simple pencil drawing, and a few pages of
generally notes and specifications in the building.
Such cases occurred to him (Mr. Harris's) certain knowledge. The
surveyor, wishing not to lose the job, takes out his quantities
on the safe side, being responsible for them to the builder.
He very naturally guards against loss to the builder, as he (the
surveyor) would have to bear the cost of the particular
members who vote for quantities not being part of the contract.
Including them in it might be very desirable for surveyors, but,
I think, it would be otherwise as regards architects.
THE CHURCH
OF
ST. HILDA, HARTLEPOOL
VIEW OF INTERIOR
LOOKING WEST.
Mr. Mathews begged to propose that the Association, having discussed Mr. Hine's paper, should give it their cordial assent. In so doing, he said, he thought the impression was incorrect that architects did not know their business thoroughly. Why should they as a rule give their drawings and specifications to a second person to go through to correct faults in them? Why should they have to write specifications and give their detailed points? He (Mr. Mathews) thought it was manifest that bills of quantities should be the basis of the contract; and, in cases where architects could find time to take out their own quantities, he considered they ought to do so. There was no better means of instructing a young man in the practical part of the profession than by taking him about on the job. The surveyor was an architect's building more satisfactory to himself, and to remove many difficulties that would otherwise arise in carrying them out. It would be more to the employer, as he would only have to pay for what he really had; and it would place the architect in a right position between his client and builder.

Mr. Lacey W. Ridge said that he understood it was generally agreed, at so late a period of the evening, to pass such a strong resolution as Mr. Mathews proposed, because it was a very important question, and required more discussion and consideration, though his own feeling was in favour of the motion. Most of the arguments which had been used had, however, been grounded on the incompetency of the system, and had been partly based on the assumption that surveyors were appointed by the architect, he was in a second degree only responsible to the architect, whereas he was not personally responsible to the builder, so that in self-defence he took the side of the builder. As a protection to the surveyor, and as leading the architect to consider what quantities had been taken out in more strict accordance with the drawing, he (Mr. Ridge) thought it would be better to make the quantities part of the contract.

Mr. Smith said, he begged to move an amendment to Mr. Mathews's motion, "that in the opinion of this Association the proposal for making the quantities part of the contract deserves serious consideration in the matter of-points of principle." In moving the amendment, Mr. Smith said that one great difficulty in the way of making the quantities part of the contract was the incompetency of certain surveyors. He had very little personal knowledge of such surveyors, but there did exist a considerable number of surveyors who took less care in their work than a very careful builder. Mr. Christian seconded the amendment.

The President said he thought it would be very unwise to carry Mr. Mathews's resolution. He thought it was absurd that an architect should be fettered in any way by the work of a surveyor over whom he really could have no control. Such would be the result where bills of quantities were made the foundation or a part of the contract, unless such bills of quantities were taken out by the architect himself or under his immediate supervision; but if they were taken out by an entirely independent surveyor, and were then made to form part of the contract, there should be any mistake in the bills, the result would be in most cases of very serious consequence, and unsatisfactory to the architect, and probably also to his client; and, at the end of the work, it might be necessary to have a re-measurement of the whole building, which would be likely to lead to much annoyance and expense on all sides; the architect would perhaps be overcharged, and the client undercharged, more than the quantity of the work. If the architect himself did not examine them, and was not incriminated, an architect could not make out fair and proper drawings and specifications, sufficient for a fair and equitable contract, without quantities, he had better have left architecture alone altogether. Some remarks had been made as to architects being a lower business class of men than formerly. His (the President's) impression was that the architects of the present day had not only considerably improved in the art, but also in the business portion of their profession, and that it was most undesirable for many reasons, which time would not now allow him to enter upon, for an architect to allow the bills of quantities—unless taken out in his own office—to form any part of the contract.

Mr. Rickman begged leave to say a few words in reply: Mr. Smith had asked him how he would apply bills of quantities in cases where the specifications and drawings were fairly made out. He was happy to say a very large number of the drawings and specifications were properly made out. In cases where the quantities were just as valuable as in the other cases. The necessity of pricing and forming an estimate involved that somebody should transfer the form of the work from drawings and specifications into the shape of a bill of quantities, unless a mershot at the value of the work was taken. The bill of quantities must be referred to in some way or other for the purpose of any variation which it might be desired to have carried out. There were quite as strong reasons at work to make the surveyor take out quantities closely, as there were to make him take them out liberally. The surveyor often took any quantities in cases where he suspected the architect of carelessness, and where he feared the builder would be down upon him for the sins of the architect.

The amendment, as proposed by Mr. Smith, was put to the meeting, and on a division was carried.

Mr. Christian said that Messrs. T. R. Smith, Rickman, Edis, and Christian be re-elected delegates to the Association for the next meeting of the Architectural Alliance, which was carried unanimously.

THE CHURCH OF ST. HILDA, HARTLEPOOL.

(With an Engraving.)

The accompanying plate illustrates the restoration about to be carried out in the ancient parish church of St. Hilda, Hartlepool, Durham. Happily, it is now rare to find a church of such ancient period in such good condition, and one in which the work of restoration should be carried out with such ample means. Its grand massiveness of effect, and its chaste ornamentation, it is considered to surpass all other churches of the county in the same period. The tower-buttresses are unique; and the piers and arches of its nave, the clerestory, both internally and externally, and its beautifully proportioned and simply adorned chancel arch, are also worthy attention.

The church was principally erected during the latter part of the twelfth century (the tower being probably a few years later than the nave), whilst the south door is of the eleventh, and the aisle windows of the fifteenth centuries. Its style is mainly of the earliest period ofyled, and the chancel. Its massive tower is cracked all directions, and has a considerable inclination to the north-east; and almost every other part of the church is in want of repair. In the year 1721, during extensive alterations, not only were the buttresses taken away from the north side, and the windows modernised in the north aisle, but the noble chancel arch of its curtail was taken out of its original length; and the present arrangement of ugly, uncomfortable pews adopted, throwing away a large number of sittings.

"This once magnificent building is marked by peculiarities of a perplexing description, and it is no easy task to decipher the intention of its architect. Especially singular are the enormously massive buttresses jutting from the tower, and the walls of each are respectively 3 ft. 9 in. and 3 ft. 2 in. thick. Whence this difference of substance arises has yet to be explained. Looking at its extraordinary form, we might fancy the design had for its object to maintain the church, consisting of nave, transept, choir, and chancel, and that, this intention being altered, the buttresses were placed against the tower to compensate for the loss of support which the complete members would have given it; but on a closer inspection of the masonry we discover portions of the walls, windows, and (upon the buttress sides) the coping stones of the roofs of three small chapels, attached to the west, north, and south of the tower, and all of the Early English period when the church was first built. The southern chapel, indeed, still exists. A survey of the tower anables us to state the extent of the buttresses, for they sustain the lateral pressure of a lofty and heavy stone-ribbed groin, which is undoubtedly the best constructed specimen of the kind in the county. This vaulting with the clustered columns from which it springs once formed a fine addition to the interior of the church, from which it is now separated by a ponderous wall of later date.

The church of Hartlepool, before the demolition of its ancient chancel, must have far excelled any of the churches in the county. The eastern sister edifice, most probably owing to the fact of its being the Bruce mausoleum, was a most remarkable building—a second church of equal length to the nave, having its columns, arches, and aisles of the same dimensions as that part, and apparently more highly decorated. About half a century has elapsed since the repulse of the invasion is said to have been seriously contemplated, but the consideration of
the subject was soon ended by the destruction of the whole, save one small compartment.

In spite of the destruction of its chancel, and the introduction of modern framed windows into the aisles, this church is still a very interesting building. Its entrance doorway is a beautiful specimen of late Norman, and the whole exterior detail, especially of some of the clerestory capitals, is of very fine character. Internally there is not so much of elaborate execution, but the capitals supporting the chancel arch are decidedly good specimens, and the small capitals indicating the continuation of some of the thin shafts is a marked singularity. A specimen of the mischmal occurs in the zig-zag of the doorway, where (against the left capital) one of the pieces of stone is left uncarved. But the most remarkable oddity is the form of the south aisle arch, at first, they would be pronounced incorrectly drawn, or if not, deformed in consequence of extraordinary pressure, but the latter is certainly not the case, as the joints are perfect, and the superincumbent masonry regular, and because there is no lateral thrust to cause this most singular deformity. The last striking feature is the cushion of the arch upon which the arches rest, but this is not peculiar to Hartlepool. Here the columns are attached alternately to octagonal and square shafts, and have circular bands or cushions enclosing the whole, both at the base and capitals. At Billingham, on the contrary, the columns are attached to a circular shaft, and the cushions are square. But Hexham Abbey, in Northumberland, offers the most important specimen, for the lofty tower piers are inclosed with a cushion similar to that of Hartlepool.

It is proposed to carry out a thorough restoration of the church, with a view to bring this noble fabric to something of its ancient grandeur, and to provide increased accommodation for the worshippers. In the nave, it is intended to take out all the present fittings and the unsightly gallery, to relay the floor at its proper level, to raise the roof to its proper pitch, to re-roof the aisles, and restore the windows both in the north and south aisles. The tower will require to be treated with the greatest care. The whole of the foundations will require to be under-pin; parts of the walls rebuilt and restored to their original design; other parts of the tower thoroughly repaired and bonded together (iron ties being used when required); and the vaulting and arches thoroughly restored. It is intended, if practicable, that the large arch into the nave should be open. These works, from their nature, must be costly; for the work will have to be carried on with every possible precaution—stone after stone being taken out and replaced in a gradual manner; as it is considered most desirable to retain as many of the original features of the fabric as possible. The chancel it can scarcely be hoped, perhaps, to restore to its original state, but it is proposed to rebuild it of such a size, that, while being sufficient for the due performance of Divine service, it may form a termination not unworthy of the splendid nave. The estimated cost of the restoration is £3000. The committees have secured the services of Mr. C. Hodgson Fowler, the architect to the Dean and Chapter of Durham.


Who that has lived in a large city has not been startled by the ominous cry of "Fire"—and who that has witnessed the disastrous effects of a large conflagration, can fail to recognise the importance of any investigation tending to prevent the recurrence of such calamities?

The title of the work before us, embracing as it does almost the entire subject of fires and their prevention, evidently requires from its author not only the most careful and studious research and examination of facts, but also the yet higher qualities of unfailing truthfulness, and a determination to maintain whatever shall condone to prevent the continual reappearance of that now almost stereotyped form of report, "Totally destroyed," or "Considerably damaged."—a form, by the way, which throws a convenient veil over the proportion of fires which result in total loss, and a great proportion of results disastrous with the distinct classification adopted in the reports of the Parisian fire establishment. In a matter involving the efficiency and management of men and appliances for the extinction of fire, too much regard cannot be paid to care and exactitude in the preparation of statements which by their bearing may tend to show where faults exist, and in what direction amendment may be looked for. There is evidently at present much room for improvement, and it is apparent that any work which, like Mr. Young's, brings together the available history and experience of fires and fire prevention from all parts of the globe, must be of essential service. The time was in our own country when occasional fires in large towns were almost necessary evils, and were to be viewed much in the same light as we look upon the loss of a limb as being preferable to the destruction of the whole body.

Of this class was the Great Fire of London, which, terrible as it was, at once purified the atmosphere, and did away with many of those miserable streets and alleys which had formed the hotbeds and nurseries of fever and plague. Unfortunately, it cannot be said that we are yet entirely free from localities so built up, so filthy, so over-crowded, and so suited in every way to foster disease and death, that a clearance, even by fire, would not occasionally appear to be desirable; but at the same time let it be remembered, that in these days we have some idea of sanitary laws, and that localities such as we have named are precisely those in which fires of any extent are least frequent.

It is not then to fires that we ought to look for sanitary improvements, but rather to their prevention, as avoiding the ruinous destruction of piles of property, and the utter and unbalanced loss of hundreds of thousands, nay millions, of pounds, which might but for fire have remained available, either directly or indirectly, for the general good.

HERCULE'S ENGINE, second CENTURY, B.C.

Mr. Young's work, which is written throughout with an evident desire to throw a clear light upon what has hitherto been but an imperfectly understood subject, commences with a chapter upon "Fires" generally, their causes, and hints most excellent in character for their prevention. This is followed by instances of large conflagrations, &c. We then have an excellent chapter upon Fire Brigades, including those of former as well as our own times, and pointing out existing defects. The succeeding chapter enters at considerable length into the means for subduing fires, and points out the weakness of the claims to originality of several so-called recent inventions. Fire-proof structures, which form the subject of the succeeding chapter, might advantageously, we think, have been treated at somewhat greater length; although, as it is, quite sufficient is said to show the fallacy of some commonly existing ideas, and to indicate the possibility of much improvement on present practice.

The succeeding chapter, devoted to the history of manual fire engines, reveals some very startling facts as to the antiquity of arrangements which we have been accustomed to look upon as being of comparatively modern origin. Of these instances the most notable is that of the air-vessel, the first use of which in connection with pumps, Mr. Young says, is usually ascribed to Leopold, in the year 1720, whereas, according to Vitruvius, the

* B. W. Billings' Illustrations of the Architectural Antiquities of the County of Durham.
honour belongs in reality to Ctesibius, an engineer who flourished in the second century before the birth of Christ; and an illustration is given of a double-cylinder fire engine, described by Hero in his "Spiritalis," with which modern improvements are in principle almost identical. We reproduce this very curious proof of the mistake we should make in supposing that ancient records can show us nothing approaching in principle to the perfection of modern practice. The whole of this portion of the work, indeed, is highly interesting, and will well repay attentive perusal. It particularly struck us that engines of the small light class, such as Robert's Gig Engine, and Merryweather's Small Manual Engine, were deserving of much more attention at the hands of fire brigades than they have as yet received, insomuch as, from their lightness, and the small power required to work them, they would be frequently available long before ordinary brigade manuals could be brought to bear, and might thus be the means of effectually keeping in check, if not of entirely extinguishing, incipient conflagrations. At a certain stage, however, the larger manuals must of necessity be called into play, and of these two excellent examples, one by Messrs. Merryweather and Sons, and the other by Messrs. Shand and Mason, are given; Mr. Young aptly pointing out the fallacy of supposing that in cases of this sort a low priced, ill-made machine can be cheap, where the greatest possible efficiency should at all times be maintained and available.

The subject of manual engines is throughout treated in a very complete manner, the progressive steps being well marked, and honour given to some who have hitherto scarcely received their due. Useful tabulated results of the performance of the principal engines at public competitions are given, and enable a clear idea to be formed of the capabilities of engines of this class, which however good, as they undoubtedly are, are after all secondary in interest for the engineer to the more effective and economical steam-power engines, to which a large proportion of Mr. Young's work is devoted, and which is of too much importance to be treated in the space available in our present number. We therefore propose to examine it at some length in our next.

THE INTERCOLONIAL EXHIBITION TO BE HELD AT MELBOURNE IN 1866.

The Colonial Government of Australia have issued a commision, under the presidency of Sir Redmond Barry, to take measures for conducting an Intercolonial Exhibition, to be held in Melbourne in 1866, and it is gratifying to find that the effort is receiving the well-merited support and co-operation of the governments of the various dependencies of the Crown in Australasia, and of friends and exhibitors in Europe and America.

The commissioners remark that, "although the contemplated display cannot vie with the splendour of those which excite the rivalry of nations, purposes of the highest utilitarian and social importance to those immediately concerned may be thereby served. A searching and penetrating attention may be concentrated on our mineral treasures, portions only of the boundless stores of which have hitherto brought to light;—on improved economic methods of winning them from the earth, and applying them to the ends for which they are intended;—on the sources of wealth which, in their raw state, abound on the surface of our soils, in the rivers, and in the waters which encircle our coasts;—and on the rare excellencies and peculiar development in different latitudes, under different conditions of culture, of those products which successful enterprise has introduced amongst us, rendering us already independent of many countries, and enabling us to contribute to the necessities, the comforts, and luxuries of most. A deliberate comparative survey may be made of the results flowing from the adoption of the liberal arts happily domiciled in these climes, and the exercise of those useful manufactures which genius, self-reliance, and perseverance, have established in lands so suitable for their natural vigorous growth. A diligent compilation of the statistics of the actual products of the productive capabilities of the different colonies will form a most valuable fund of information. It is proposed to distribute the objects to be displayed into the following divisions:—Mineral products, animal products, vegetable products, manufactures and the useful arts, ornamental arts, machinery.

The commissioners particularly desire to induce patentees of mining machinery in Europe and America to forward, for exhibition, models of their working machinery. More especially that class coming under the head of Rock Boring, Tunneling, and
Coal-Cutting Machines. The importance of the introduction of such machinery into the colony cannot be too highly rated, as it will render productive vast tracts of arid and useless land now considered too poor to work. In quartz mining, which is daily affording instances of its permanent character, inventions of this sort would make such a reduction in the cost of sinking, driving, and stoping as would in many instances double the dividends to the shareholders. The coal-complaints of the coal-owners, that their machinery is not adapted to alluvial mining, and with slight modification might be used in almost every operation, it being especially suitable for breaking out loose and treacherous ground without risk to the men attending it. Another kind of machinery it would be desirable to have represented would comprise every invention more particularly used for hydraulic mining in California. The steps now being taken for supplying the goldfields with water will no doubt cause such machinery to be in great demand. Considering the probability of the exhibition attracting from the adjacent colonies a large number of visitors, more or less interested either practically or financially in mining pursuits, a more favourable opportunity could hardly be suggested for such a display.

The Juror's reports at the International Exhibition, London, 1862, directed particular attention to the great importance attached to Australian mineral products; and any who have read the detailed reports will see that the design of improvements in mining machinery are invited to the field which is here open. It is really a most important subject, both in regard to the machinery, especially those adapted for boring and tunnelling for gold, quartz, coal, copper, and other minerals. The Commissioners desire to exhibit all the mechanical improvements of this kind that can be gathered together, believing that by so doing the interests of the colonies, as well as those of the home manufacturers, can be greatly promoted. The practical working models would be equally acceptable; and as the building in which the exhibition will be held is to become hereafter a public museum and department of industrial art, such mechanical illustrations could be made permanently accessible to the public, thus securing a publicity far beyond that of the few months during which the exhibition will be open. According to the wish of the exhibitors, the goods would be thus received for permanent exhibition, or at the close of the present one be handed over to any person authorised as agent.

Although the scheme of the Intercolonial Exhibition is strictly to encourage colonial produce, the importance of possessing the highest class machinery for mining purposes is a sufficient reason for inducing the Commissioners to make this branch an exception to the general rule. The models or machines can be received at Melbourne up to the end of September next.

The Secretary to the Commissioners is Mr. J. O. Knight, F.R.S., of the Melbourne School of Mines, who represented the Australian Colonies at the London International Exhibition of 1862. The offices of the Commissioners are 64, Elizabeth-street, Melbourne.

JUDGMENT RESPECTING CERTIFICATES UNDER A CONTRACT.

The following report of a decision of the Court of Common Pleas, Dublin, on the 2nd ult., is of importance to members of both professions, engineers and architects, as well as contractors. The defendant was Mr. John Bower, C.E., Dublin. The case was tried before Chief Justice Mahan, Judge Keogh, and Judge Christian.

Murphy v. Bower.

Their lordships delivered judgment in this case, which was argued last term, and stood over. It came before the court upon a demurrer to the defendant'splea of summons and prayer. There was an action by the plaintiff, as assignee of Messrs. Edward, John, and Patrick Moore, railway contractors, against the defendant, who is a civil engineer, to recover damages for not giving certain certificates under a contract. The summons and plaint contained three counts. The first, after stating the pecuniary embarrassment sustained by the plaintiffs, Moore, and the plaintiff as assignees, stated that the defendant was duly appointed civil engineer of "The Finn Valley Railway Company," in the north of Ireland, and, while so acting, a contract was entered into between the Messrs. Moore and the railway company for the construction of the railway, for a sum of £2,000, and further sums for extra works, payment to be made in monthly payments of not less than "nine-tenths" of the value of the work done, the balance to be paid on completion, on the production by the contractors to the railway company of proper certificates from their engineer that the work was all done and completed. That the defendant gave certificates to the extent of about £18,000, but declined and refused, when called on, to give further certificates, although the amount fairly due on foot of the contract and extra work was about £26,000, thereby leaving a balance of about £7000 due to the plaintiffs as assignees of the contractors. The second count of the defendant's plea was similar, but in addition, imputed fraud; and the third, which was also similar, charged collusion between the railway company and the defendant. The defendant demurred to the summons and plaint, on the ground that a contract to a fact should be distinguished. It was not so stated that the duty was necessarily imposed on the defendant to grant a certificate, and that the defendant was no party to the contract, &c.—Their lordships allowed the demurrer, with costs.

—Carlow Sentinel.

Railway Bridges in the Metropolis.—The question of noise from passing trains, so much complained of, was recently raised between Mr. Schoele, chairman of one of the Commons railway committees, and Mr. Hawskaw. Mr. Schoele desired to know whether the noise consequent on the passing of trains on rail bridges could be reduced. The Hon. Mr. Hawskaw gave it as his opinion that this excessive noise was mainly due to the construction of these bridges being entirely of iron. He stated that this mode of construction was insisted on by the parochial authorities; but that if these bodies would allow the bridges to be made of brick or stone, as it is believed would be the case, the noise caused by passing trains would be very little, and indeed, with proper precautions, might be almost entirely obviated.

New Iron-Preserving Agent.—Dr. Henry Edward Francis de Broiu, a Parisian physician, who for many years has resided in England, has discovered and patented a process for preparing from India-rubber what may be designated an "enamel paint," which is said to be proof against the action of the atmosphere, as well as against the power of all liquids to affect iron. This enamel paint possesses all the remarkable qualities of India-rubber, without combining with them any other substance or element that is calculated in the slightest degree to counteract their thoroughly efficient operation. The preparation is applied cold and in a liquid state, and in consistency and general appearance it resembles such common oil-paint as is ordinarily used for ironwork. It may be applied with ease. The covering may be so thin that its presence cannot be detected; while it leaves the protected surfaces in all their original sharply-defined freshness. It hardens also at once, and immediately forms a smooth and lasting coat almost like a well-made oil varnish, water-proof, and acid-proof. Thus protected the iron is safe. Rust cannot accumulate upon the surface of this enamel-paint, nor corrode beneath it.—Art Journal.

Archaeological Discovery.—An important discovery has just been made in Egypt, at Chafouf, a station some leagues north of Suez, where a monument of Persian origin has long been known to exist. A copy of some cuneiform inscriptions found there having been sent to M. Mariette, that gentleman inferred from certain indications that a portion in hieroglyphics must still remain below the surface of the soil. He accordingly communicated his conjecture to M. de Lesseps, who ordered excavations to be made, which brought to light a translation of the cuneiform writing in Egyptian hieroglyphics. The stone bearing this bilingual inscription, which belongs to the reign of Darius, will shortly be conveyed to the museum of Boulogne.

A Rotary Rock Boring Drill.—Among the patents recently issued at Washington is a rotary rock-boring machine, which consists of a drill composed of a number of scoloped cutting wheels, arranged in a common head, on axles passing through the right angles, in such a manner that by giving the head a rapid rotary motion, the wheels will cut into the ground or rock and produce a clear hole. The dirt is raised by the action of a spiral flange, secured to the outside of the drill rod, guided by friction rollers. A stream of water is made to pass continually to the bottom of the hole through the drill rod, which is made hollow for that purpose. Much of the dirt is thus removed.
ARCHITECTURE AT THE ROYAL ACADEMY.

Year by year, the hold of architecture upon the Royal Academy, and upon its “Exhibition” in particular, appears to become gradually and hopelessly lessening. We have on many bygone occasions alluded to this fact, with the hope that, if the Academy as a body did not change its mode of proceeding, such of its members as belong to our profession might be stimulated to, at least, an open protest, which, backed as it would doubtless be by the influence of less privileged men, in the course of time, hardly fail to ensure some more worthy recognition of an art which, with sculpture and painting, has an equal claim to consideration, if only on the ground of the original Royal Charter to the Institution. Granted that the demand for, and interest in, historical pictures and landscapes is greater than for the more conventional, and homely procedures of sculpture or architecture; yet surely, after making every allowance, the preponderance is far too great when we find that, out of 1,063 subjects exhibited this year, 798 are devoted to painting, 214 to sculpture, and only 40 to architecture! We are quite aware of the difficulty as regards finding space in the already too crowded rooms, but we plead to a more just distribution of heat space, and shall look forward with hope to the influence of the newly-elected “Professor” of Architecture, and the newly-elected “Associate,” to bring about a better state of things for the future, be the ultimate destination of the Academy Burlington House or the Royal Hospital, “which is to be erected at Stangate, and on the banks of the river, facing the Houses of Parliament. This building will be remarkable for the extent of area occupied, and for the classification of its internal arrangements, in conformity with the most approved sanitary measures and complete system of ventilation (773) exhibited by the architect, Mr. F. P. Cockerell. In its design, it gives to the character of the effect to the whole heart of the place, with its own requirements, has been so usual now a-days, yet not without some judicious variations, especially in the introduction of various symbols and devices identified with the Masonic craft. (774) shows another of the many comprehensive schemes which have been before the public for a viaduct across the Holborn Valley. The design before us, by Mr. Horace Jones, and apparent to have been studied with care and judgment. The question of cost might operate as a check to its being carried into execution, but it is high time that decisive steps were taken to improve the locality in some way or other. (776) we can hardly realise the “Parish Church, Leamington,” as proposed to be altered by Mr. Street. The place where it exists, was once the Vicar of Leamington—an amateur architect—and is based very much upon Continental examples. It has, however, never been finished, although suggestions innumerable have been sought and obtained for the purpose. A Palladian design, on an extensive scale (777), exhibits Mr. H. Jones’s excellent design for the “Metropolitan Meat and Poultry Market,” proposed to be erected at Smithfield, which we should be glad to see erected on the same site. Both the plan and the elevation (Palladian) are much too be commended. Mr. Marrable’s “Chancel of St. Peter’s Church, Deptford,” (778) is, fortunately, hung so high as to make the finest exhibit of its kind that we have noticed, being a fine example of the skill and taste required, show out sundry architectural features deserving more of the blame than the praise of novelty. It is a pity that such a drawing should have found a place here at all, when so many more meritorious works have been excluded for “want of room.” St. John’s College, “Hurstspoint,” (779) by Messrs. Slater and Partners. A skilful and well-constructed building, the proportions generally are very satisfactory, and the fittings are designed in harmony and good keeping.

Views of the two chief designs for the “New Midland Railway Terminus and Hotel,” to be erected in the Euston-road, St. Pancras, are exhibited side by side in (780, 789); the former being the designs of Mr. Dignam, and the latter, of Mr. Scott; and the latter, by Mr. G. S. Clarke, having received the second premium. There is, at first sight, a degree of similarity between these two designs, so far as the massing is concerned, and that each is treated as a mask or screen, which in no way identifies itself with the ordinary aspect or purposes of

we have just quoted? The detail, moreover, seems not a whit better than the outline, being of that peculiar kind once described by a well-known art writer as “pastiche.” More satisfactory is Mr. E. M. Martin’s design for the National Government, for the completion of the New Palace at Westminster, on the removal of the present Law Courts, and which is shown, in (780, 775); in plans, elevations, and sections, though, unfortunately, to a very small scale. It is apparent, however, that the general character of the late Sir Charles Barry’s work will be continued, and he has added, among other things, a large quadrangle between Bridge-street and New Palace-yard, also a subway from the House of Commons to the Thames Embankment, and to a new railway-station on the north side of Bridge-street. The latter is proposed to be Gothic, in harmony with the rest; but it would surely be allowable, if not desirable, to break the monotony by designing the station in an entirely different style, especially as the adjoining building already suffers much from over-repetition of parts.

Mr. W. White sends (789) the perspective view, which should have accompanied his geometrical drawings, of his “New Church, Aberdeen Park, Highbury,” to the Architectural Exhibition. Mr. the group effect is quite what might be anticipated from the scale drawings, and we regret that, in the too great straining after novelty, so much that correct taste would have expunged has been permanently identified with the building. The largest and most important of the architectural pictures (773) is for a new Hospital, “which is to be erected at Stangate, and on the banks of the river, facing the Houses of Parliament. This building will be remarkable for the extent of area occupied, and for the classification of its internal arrangements, in conformity with the most approved sanitary measures and complete system of ventilation (773) exhibited by the architect, Mr. F. P. Cockerell. In its design, it gives to the character of the effect to the whole heart of the place, with its own requirements, has been so usual now a-days, yet not without some judicious variations, especially in the introduction of various symbols and devices identified with the Masonic craft. (774) shows another of the many comprehensive schemes which have been before the public for a viaduct across the Holborn Valley. The design before us, by Mr. Horace Jones, and apparent to have been studied with care and judgment. The question of cost might operate as a check to its being carried into execution, but it is high time that decisive steps were taken to improve the locality in some way or other. (776) we can hardly realise the “Parish Church, Leamington,” as proposed to be altered by Mr. Street. The place where it exists, was once the Vicar of Leamington—an amateur architect—and is based very much upon Continental examples. It has, however, never been finished, although suggestions innumerable have been sought and obtained for the purpose. A Palladian design, on an extensive scale (777), exhibits Mr. H. Jones’s excellent design for the “Metropolitan Meat and Poultry Market,” proposed to be erected at Smithfield, which we should be glad to see erected on the same site. Both the plan and the elevation (Palladian) are much too be commended. Mr. Marrable’s “Chancel of St. Peter’s Church, Deptford,” (778) is, fortunately, hung so high as to make the finest exhibit of its kind that we have noticed, being a fine example of the skill and taste required, show out sundry architectural features deserving more of the blame than the praise of novelty. It is a pity that such a drawing should have found a place here at all, when so many more meritorious works have been excluded for “want of room.” St. John’s College, “Hurstspoint,” (779) by Messrs. Slater and Partners. A skilful and well-constructed building, the proportions generally are very satisfactory, and the fittings are designed in harmony and good keeping.

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a railway; the buildings themselves being on so gigantic a scale that even the arched approaches to the terminus in the rear, though large in themselves, are comparatively lost in the comparison, and we can simply say, "To Church, then (287), or, "Taller still, and a still better drawing (293) of the "Tabernacle in Louraizian Cathedral." The "Interior of Lierre Cathedral" (790) strikes us as less happily managed, although the scale price is put down at a large figure. As a bit of correct, unpretending colouring, nothing can be better than Mr. H. Hawkins's "Interior of Edinburgh Church," "Markets" (of 2); which, as usual, are the "character" (790), and more picturesque, are Mr. S. W. Boden's "Old Cottage at Cluddingbold, Surrey" (923), and his "View of the Village of Chiddingfold" (957). "Ogmore Castle, Glamorgan" (853), by Mr. E. W. Robinson, is nicely handled; and so are "Armdecastle" (880), by Mr. C. Pyne, and all Saints Church, Hastings (338), by Mr. Dukin. Mr. Dobbin, in his "City of Prague" (940), gives a very careful and interesting bird's-eye view, embracing several well-known buildings. This drawing is in every way superior to the larger one by the same artist (1035) representing the exterior of "Seville Cathedral," the effect of which is hard and dry. So also his "Archbishop's Palace at Ligue" (948) has little of interest about it except the curious outline of the pillars which form the support to the cloister round the quadrangle. (969), a large drawing by Mr. J. C. Swallow, shows the "Palace of the Stuarts, York," an edifice built by James 1st, partly on the site of the Abbot's House and the Lord Protector's Palace, while the materials were chiefly supplied for the building of Mary's Abbey, close adjoining.

Mr. W. W. Deane has a fine interior view in oil (943) of "St. Mark's Venice," while Mr. W. Henry exhibits (318) the everlasting "Cavelli Palace and Church of Santa Maria Salute." Miss Louisa Kayner sends, as usual, painstaking and effective studies from ancient buildings (1074) in some Old Houses in Edinburgh, (411) is "Rosslyn Chapel," an interior view, interesting as having been the last view painted on the spot previous to its restoration.

AKROYDON, NEAR HALIFAX, YORKSHIRE.

(With Engravings.)

AKROYDON is a village in the suburbs of Halifax, which derives its name from its founder, Mr. (now Colonel) Akroyd, M.P., at whose sole expense the neighbouring beautiful Church of All Souls', Haley-hill, was erected some years ago. The arrangement of the buildings at Akroydon has been based on a well-studied and convenient plan, embracing every essential to the health and comfort of the inhabitants, and the undertaking, which has proved in every way successful, is now in a forward state of completion. The general scheme of the plan may be described as occupying a rectangular area of about 800 feet deep, by a frontage to the main road of rather more than 600 feet. It consists of a double row of dwellings on three of the sides, and of one parallel range of houses towards the north. The ground slopes rapidly from east to west, and the centre of the quadrangle will be railed in and turfed, and there will be a handsome fountain at the intersection of the crosswalks. All the buildings are being carried out in the most substantial manner, and with due regard to correct, although simple, external effect. The designs, in some respects, vary in the different blocks of buildings, but those which we have selected for illustration will give a good general idea of the whole. These plates form part of a series illustrating a thoroughly practical volume on "The Homes of the Working Classes," by Mr. J. H. Colson, which was reviewed in this Journal in the January and February numbers of this Journal for the current year, and to which we may refer for additional particulars. The accompanying illustrations have been kindly furnished to this Journal by Colonel Akroyd, in answer to a special request, inasmuch as we are anxious to bring to notice, for general application, a few of the improvements made from time to time at this national workhouse—a working-man's dwelling. The problem which Mr. Akroyd set himself to solve cannot be better stated in his own words:

How a limited outlay of capital may materially assist in raising the general standard of workmen's houses in any locality to an extent far beyond the ordinary limits.
departments of art-workmanship can hardly be expected to entirely escape. An opinion is becoming very general that most of the building trades have deteriorated in quality, and painting, as one of them, is not so well executed as it used to be. Anyone who is accustomed to observe these things feels that there is something in the case, and Mr. Akroyd, in his address to himself and the other members of the Halifax Building Society, which would advance three-fourths of the capital required.

Mr. Akroyd bought a suitable plot of land, obtained designs not only excellent in a sanitary point of view, but also architecturally beautiful. He undertook to give plans, to defray all expenses of supervision and guarantee the fulfilment of the contract within the estimate. These were liberal concessions; but a more important one still remains to be mentioned. The purchaser is of good character, but unable to advance the one-fourth of the purchase-money, the payment to the building society is spread over fifteen years, instead of twelve years; and Mr. Akroyd guarantees the first three years' subscription to the building society, after which his guarantee ceases, as the building society then possesses sufficient security against loss, in the mortgage of the property.

The first two blocks erected comprise eighteen houses, which vary materially in the cost. Upon the original plan there were provided one living-room, 16 feet 6 inches by 11 feet 6 inches; and a small bedroom, 11 feet 6 inches by 6 feet 6 inches, with scullery or wash-kitchen under. All are single houses, solidly built of the stone of the country, and covered with slate, presenting a neat, pleasing exterior (see plates 23, 24, and 25). At the back of the house is a back yard, with a back door and a cellar, and a separate back entrance. Water, for general purposes, is supplied in pipes to every house, and the proper drains have been carefully laid down, with sanitary tubes. Gas, from the borough, is also conveyed to each house.

The number of dwellings erected up to this date is 88, including a large and commodious store, the property of the Halifax Co-operative Society. The dwellings erected are in six blocks, and are of several classes in each block, varying in cost from £186 to £240. The £186 represents the No. 4 class, the £240 the No. 1; the intermediate cost is £154, £190, £220, £240, £290.4* Of the pecuniary success of the scheme Mr. Akroyd thus speaks:

It has been already intimated that this class of model dwellings will not pay as a commercial speculation. The proprietors have no reason to complain if they can realise 6 per cent. upon their investment upon a house so well and substantially built that for many years the cost of repairs and rates will be insignificant. I cannot admit that the price of land in this country will maintain a house at the first block, giving the land required for the streets. This is not surprising. At present the working classes are so little accustomed to a really good house, of a pleasing elevation, and fitted up with every convenience, that they are unwilling to pay the increased cost. I am prepared for this result; and therefore offered a premium to the proprietors of the first blocks, to secure their erection after my own design. I am sanguine that the houses will advertise themselves, and obtain such a rental as will enable me to protect myself from material loss in future blocks, and yet ensure to the proprietor or member a good return for his outlay.

Mr. Akroyd suggests that under this system the munificent donation of £150,000 by Mr. Peabody to improve the dwellings of the poor of London, if thus supplemented by benefit building societies to the extent of three-fourths of the value, might have been the means of building four times the amount of houses, assuming that a sufficient number of working men could be found to take up the work.

PAINTED DECORATION.  

By Mr. S. Fisher.

Before commencing a description of the various methods and materials employed in painted decoration, I wish to refer to painting as a branch of the building trade, as this and decoration are so intimately connected that it is worthy of more consideration than it generally receives, especially since in the present day the greater feeling which prevails for art in every shape and form by the public, the tendency to preserve; whether posterity will be of the same opinion with regard to what we do is a matter of uncertainty; but, as Mr. Burgus has said, one of the acts of the next generation will be to destroy all the painted windows executed in this, other

* Paper read before the Architectural Association.
where, are not calculated to impress us very favourably with this method, but under certain circumstances it is a very valuable one—for covering large surfaces with merely diaper patterns, there is a superiority of texture about fresco to any other medium. With a dry wall to start with, and proper precautions being taken with reference to the time of the year, the plaster may be left to rest in the open air, and I believe it will last as long as the plaster. I have used this method largely for some years, and have great confidence in it as an inexpensive and effective means of decorating in a simple way the walls of churches, or for halls, corridors, &c., in places where it is wanted—and happily as soon as anything more than mere diaper patterns are wanted—the difficulties of fresco-painting commence; the small number of colours that may be really depended on to withstand the action of time, cramps the artist in his design to begin with. The necessity of finishing every part of a day's work to the minutest detail before proceeding to the next, renders it impossible to make any alteration as the painting proceeds; and there are very few artists who would not consider it an advantage to be able to return and tone down, or alter certain portions of their work; but retouchings are impossible in fresco, except at a sacrifice of all transparency.

The artist would make light of these difficulties, but he needs to be a really great one, and he wants a means of decoration that can be employed by one of more moderate calibre. The establishment of Schools of Art throughout the country, by placing the means of education in drawing and painting within easy reach of everyone, must ultimately result in artists engaging in the fresco medium, and if the ordinary artist is able to place himself a higher class than we have been in a general way accustomed to; and many persons who would have looked upon the clever imitation of woods and marbles as the greatest result to which an ornamental painter could arrive, will, in consequence of these facilities, become capable of producing something more worthy in an artistic sense.

It must be understood that I am not endeavouring to underrate the skill of our best imitators of woods and marbles, for some of them execute work which is so beautiful as almost to justify us in preferring shams to truths, and altogether different to the vulgar we see so much of; only it must be admitted, without entering upon the question, that the textures, and there are, or should be, objects in decoration which the best imitative painting will not supply.

It is rather curious to note that the rise and progress of graining and marbling have so nearly kept pace with that of false marbling, and with the search of every new variety of artificial texture. The most beautiful and best preserved of all the city's woodwork, is of very modern date. There used to be a process, called graining, which was extensively employed in house-painting in this country from the earliest times, which was perfectly guiltless of being an imitation of anything under the sun; and some of the finest that have been done by the purer artists, in their best periods of art, merely as a suggestion. But it remained for our generation and country—for it is peculiarly an English art—to adopt it almost to the exclusion of every other. About seventy years ago, the idea appears to have struck the decorative painters that they might improve upon their work by making it more natural, and the first attempts at this were so highly appreciated, and exceedingly well paid for, that a race of artists sprang up who each improved upon his predecessor, until that which was originally a clumsy, conventional imitation, and pretended to be no more, became an exceedingly clever work; for, though it has become somewhat the fashion since the Renaissance of Gothic to despise graining, to execute such work well requires great patience and skill and a fine eye for colour—the same qualities which, directed by the Government Schools of Art into another channel, will develop into a class of artists able to compete with those of any country or period. Supposing that all the manipulative drawbacks of fresco could be easily surmounted, we should still remain unable to affect the fluid; and not yet been made permanent. The earliest fresco-paintings in any public building in this country of which we have any account are those by Aglio, in the chapel at Moorfields; they consist of, or rather did, an enormous picture of the Crucifixion, occupying the entire space of wall at the east end of the church. This was painted in 1590, in fresco, and was a very few years afterwards, repainted in oil colours, in consequence of the fresco picture almost entirely disappearing. This oil-painting was obliged to be restored by the original artist in 1837; and, upon the chapel being repaired eight years ago, it was cleaned and varnished, and has now a glossy surface, which magnifies all the irregularities of the plastered wall, and completely destroys the effect of the picture in most lights. And the ceiling, which was painted at the same time as the first work, and appears to have been left in the original condition, being almost indistinguishable, it was cleaned and restored in distemper colours, and in as coarse a manner as could well be conceived. The painting on the east wall is an excellent example of how unsuitable a medium is for mural painting, the effect being evidently very different to that intended by the artist, and it is stated that it was the first paintings that survived. The Church of All Saints, Westminster, painted by the late Mr. Dyce, were two years ago, obliged to be repaired. These are painted upon a thoroughly sound and dry wall—the temperature of the church must be tolerably equable—and we may fairly conclude that every precaution that could be thought of was taken to render them permanent; but the fact that a restoration was necessary so soon after they were painted, taken in connection with the state of the frescoes at Westminster, is a very convincing proof that the process is not a suitable one for us. There is a very fine picture in fresco painted by a German artist, whose name we do not know, over the arch of the Church of the Redemptorist Fathers, at Clapham, which shows unmistakable signs of decay, and that has been painted only some ten or twelve years. Therefore, that the artists engaged at Westminster are justified in abandoning a method which has been proved unreliable is without doubt; but the question then arises: why was it not discovered, and we which is in every respect better is, I think, by no means so certain. This vehicle is as regards its permanence really yet an untried one; and that it has been found to stand in Germany is no proof that it will do so in our moist climate, and even there, about 20 years is the extreme time-test to which it has been subjected. The first experiment with the manufacture and application of this vehicle to painting were made public by Dr. Fuchs in the year 1826, but at that time did not appear to attract much attention; and in 1859, an elaborate and exhaustive description of his invention was translated by desire of the late Prince Consort, and published in the Journal of the Society of Arts, which was the first time public attention was called to the method in this country.

The process of stereochromic painting—as it was named by Dr. Fuchs—found to be the best, is to paint upon a plastered, or other absorbent surface, in colours mixed with water only—that is, with water, or an adhesive medium, and, when the painting is properly finished, to cover it with a syrup, perforated with a number of small holes, in order to get a very finely divided stream, with a solution of water glass, till absorption ceases; the more absorbent the surface painted on, the more perfect is the operation. It has been found impracticable to apply this to walls, but the results have been obtained in the manufacture of papers, where the colours, on account of its stiffening the brush, and setting before the painting could be accomplished by the most rapid execution. The result is really a water-colour painting which will bear washing without injury, and resembling fresco, excepting in the luminous quality so peculiar to the latter; but whether it will remain with that desirable property we have yet no adequate means of judging with certainty. If some of the solution is placed in a shallow vessel, or spread upon glass, and allowed to dry, it will appear at first like a colourless varnish, and extremely hard; but after the lapse of a few days it seems exceedingly sensitive to atmospheric changes, becoming in damp with almost every imperfection. It is also after a short time semi-opaque, or milky in appearance. In a state of fluid, the constituents of water-glass have a feeble affinity for each other, and are so easily acted upon by acids, that the smallest quantity added to the solution will immediately precipitate the silica in the form of an opaque white substance, which may be destroyed with an effort, and whether the carbonic acid with which the atmosphere of all public buildings is so highly charged will not by slow degrees produce the same effect is a question that time only can decide. This soluble alkaline silicate—as it is chemically termed—is really the same composition as glass, with just so much alkali in excess as renders it soluble in water in the first instance. It undergoes no chemical change upon its application to the painting, therefore the same influences must always affect it, though
perhaps in a less degree, and it is a matter of grave doubt whether it will be found ultimately more durable than fresco. The various inventions for the preservation of stone are all analogous, and it is used as a medium which is always brilliant. When an oil painting at twilight begins to become indiscernible to the eye, a wax painting next to it is still clearly visible.

The modern revival of encaustic painting dates from about the year 1829, when Montabert, in his "Complete Treatise upon Painting," extols it above the art of oil painting. But previously to this the late Mr. Cayley commenced experiments to recover the lost art; and the Count exhibited a head of Minerva, painted in the ancient manner, in 1764, which was much admired. From this time efforts were made to revive encaustic painting at Venice, Verona, Milan, and Rome, in each of which cities several works were executed. But after a time the method seems to have been again abandoned, from what causes I have not been able to ascertain. It was again revived at Munich, by the modern German School, under the patronage of the late King Ludwig, and large works were executed there, also at Berlin, Heidelberg, Vienna, and other places where the influence of that school penetrated. At Paris, the Churches of La Madeleine, Notre Dame de Loretto, St. Vincent de Paul, and other public buildings, are decorated in this mode; but no one example has ever, to my knowledge, been executed in England. I consider, therefore, we are justified in thinking this to be a vehicle that has been singularly overlooked, more especially as I believe it to be the only one that is not subject to any of those disadvantages of any breadth or simplicity of treatment, or the utmost amount of detail; it allows of the use of any colours that may be employed in oil, and even more; and, above all, if the ground is thoroughly dry (not an impossible condition), there is scarcely any limit to its permanence. The singularly preservative action of wax on all colours, even on those which are fungous when used in other mediums, keeps the artist's design in all its original freshness for any length of time, as it undergoes neither shrinking or expansion from any alteration of temperature, wax being perfectly indifferent to any atmospheric changes. And as the wax is impervious to the action of the atmosphere, no combination entirely prevents any contraction of the plaster afterwards, resulting in the cracks so destructive to fresco painting, nothing short of violence can injure it.

The process of encaustic painting is as follows:—The surface, whether of plaster or stone, to be painted on, is heated to the point of melting the wax, and is then covered with a layer of white wax, powdered with charcoal or tobacco, and dissolved in turpentine, which is the medium to be used throughout the work. The addition of gum to the wax is necessary, as, alone, the wax would be too soft to work upon pleasantly but; any increase in this quantity of gum has a tendency to crack when the colours are laid on in any body. The employment of gum copal, or elemi, as being harder gums than damar, is preferred by some. Mr. Gambier Parry's medium is of this kind; but as he omits altogether from his formula the agency of heat, either to combine the finished work with the under-coats, or for the preparation of the wax, and also lessens the quantity of wax, his is considered the more durable, and the more difficult to deal with, they require a stronger solvent than turpentine, or that a little oil should be added to the composition, which is most important—on account of its tendency to darken—to do without; when used, they are no more impervious to damp than damar; and that they should be less soluble in turpentine. If a portable charcoal fire till can be secreted near the hand upon it. A greater heat will not have the effect of causing the solution to penetrate any further than a moderate one about one sixteenth of an inch is the utmost depth to which a common red tile will absorb it, when made nearly red-hot.

It is then to be thoroughly saturated with a mixture of about two parts of colour and one part of turpentine, dissolved in turpentine, which is the medium to be used throughout the work. The addition of gum to the wax is necessary, as, alone, the wax would be too soft to work upon pleasantly but; any increase in this quantity of gum has a tendency to crack when the colours are laid on in any body. The employment of gum copal, or elemi, as being harder gums than damar, is preferred by some. Mr. Gambier Parry's medium is of this kind; but as he omits altogether from his formula the agency of heat, either to combine the finished work with the under-coats, or for the preparation of the wax, and also lessens the quantity of wax, his is considered the more durable, and the more difficult to deal with, they require a stronger solvent than turpentine, or that a little oil should be added to the composition, which is most important—on account of its tendency to darken—to do without; when used, they are no more impervious to damp than damar; and that they should be less soluble in turpentine. If a portable charcoal fire till can be secreted near the hand upon it. A greater heat will not have the effect of causing the solution to penetrate any further than a moderate one about one sixteenth of an inch is the utmost depth to which a common red tile will absorb it, when made nearly red-hot.
regularly and slowly by means of the brazier. It is sometimes the practice, before this final heating, to varnish the whole surface with the wax medium; but if the wall, before commencing, has been thoroughly saturated, and a sufficient of it has been used with the colours in working, this step will not be found necessary. The result of this burning in is, that the finished painting, the ground, and the preparation of the wall, are all melted and amalgamated together in one homogenous substance, united to the wall in the most perfect manner, and remaining brilliant and imperishable. I have had considerable experience in all kinds of mediums, and have always found them unsuitable for the purpose. I feel inclined to think that one of them is so suitable or so trustworthy as encaustic when properly executed.

Distersper is a perfect style for mural painting as regards brilliancy of colour, and flatness, or absence of gloss, but is liable to injury from moisture, whether arising from condensation or any other cause, and can never be properly cleaned. There is another cause, too, of its want of permanence which we are constantly meeting with in the remains of mediaeval painting, and which consists of the decay of the size or gluten used to bind the colours, which in some places is so great as to leave them a mere dry powder on the walls, and in others having so slight a cohesion as to drop or drift in flakes at a touch. How much richer we should have been in these examples if the artists of the middle ages had been acquainted with the virtues of wax painting, which no superincumbent costs of whitewash could have injured. In the Lady Chapel at Winchester there are some wall paintings in better preservation than usual, and I fancy they are reflective on the careless way by the attendant verger. I imagine to be a species of encaustic, but of this I am not sure; they are, however, certainly worthy of careful examination. Oil will bear any amount of washing, but from its tendency to change colour and become horsey in texture, and from its glossy surface, is the most unsuitable vehicle of oil, almost as luminous as fresco, and (if required) as perfectly flat, but it is also capable of receiving just as much, or as little, gloss as may be wished to give richness to the darker colours, by simply polishing with a cloth; and in certain positions this may prove a great advantage. Whatever medium may be chosen for painting with, the utmost perfection of the encaustic is a perfectly dry ground; without this, no painting of any kind will be permanent; and, where there exists the slightest doubt upon this point, the best way is to cover the wall before painting with canvas, fastened on with a cement composed of red lead and oil, which hardens to a perfectly impermeable substance, so that, if the wall should, after painting, become damp, the painting can be easily removed without injury, and re-attached when the ground is considered safe. This plan has also the advantage of enabling the artist to work in his own studio, as the painting may be fixed in its place just as readily when finished as the unpainted canvas. Of course, encaustic paintings cannot be executed upon a ground of this kind, but we may still have the benefit of wax as it is commonly employed by painting on an oil basis.

I have confined my remarks almost entirely to the executive processes of the work, without touching upon the art questions of colour or treatment, in the thought that it would be the more acceptable form in which to treat the subject.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

The Institution of Civil Engineers of Ireland held its last annual meeting in the Museum Buildings, Trinity College, Dublin, on the 1st of May. Mr. Henry Martell, F.R.S., delivered an able address, of which the following is an abstract:

The President's Address.

Ours is the age of material progress, which reflecting men begin to see necessary involves with it changes and progress in the world of mind and of spirit the most searching, fundamental, and unexpected. Social habits and politics; commerce, domestic and international; the modes of taxation, the diffusion of knowledge, the planting of the waste places of the earth; the conduct of war, its weapons, its modes of attack and defence; the artificial barriers set up between classes, the antipathies of caste; the ceremonies that await the sepulture of the dead; the beliefs of the body and of the soul, of faith and of worship—all are being kneaded beneath the unseen but resistless influences upon them of those palpable and material powers over time and space, and weight and matter, which have been evoked by the engineer within the last eighty years.

Many of the moral and physical changes being effected by the art of steam and by the force of steam alone, are of a character that no man could have foreseen; and, startling as they already are, foreshadow others still greater, and seem to point out to us clearer notions as to the nature of the forces which really govern the world and determine its progress than we had been taught previously.

It might possibly have been foreseen that the steam-ship and the railway would in time enable the luscious fruits of the tropics, within a few weeks of their having been gathered in the sun, to be eaten amidst frost and snow by the fur-clad Russian; that the pine-apple, the very symbol, but a generation ago, of the rich man's feast, should be sliced and sold from barrows in the streets of London. But the great railway is destined to be the real missionaries; and that under the levelling influence, without persuasion or compulsion, of this new power to move and travel, caste, and the theologies and creeds to which it belongs, social ceremonies and systems bound up with these, all of them the most ancient of which we have any certain historical record, are being melted away and moulding themselves into new and more true and living forms?

But I must forbear to enlarge upon the tempting theme of the mental and moral effects upon our race of material progress, as especially urged forward by the engineer, which, in its silent but powerful action, seems to underlie all other progress, and like the stone cut out without hands which the Chaldees saw launched through the midst of heaven to fall upon the earth, the destined instrument to break in pieces the brass and the iron and the miry clay of the feet of that Colossus of ignorance, falsehood and violence, that still tyrannizes over and oppresses the one and all.

It is but thirty years since railways commenced to be a mode of travelling, yet already more than ten hundred millions of money have been expended in spreading upwards of seventy thousand miles of lines over our globe. Each year adds largely to the total. Within the last two years Parliament has either sanctioned, or has been applied to for sanction, for nearly 270 miles of new lines to be laid down in the suburbs of London. The capital necessary for those sanctioned is about twenty-one millions, and that for those now before Parliament, nineteen millions, or a total outlay of forty millions in and about London alone. Amongst these projects are embraced two new tunnels under the Thames, and five new bridges over that river.

If we look to our progress upon the water, we find that we are adding to our mercantile marine at the rate of more than a tonnage of 200,000 tons per annum, of which nearly one-half the ships are built of iron. This is exclusive of ships of war, of which, in armour-plated vessels, our own and the French navies combine to spend many millions besides, the cost of each of which may be reckoned by hundreds of thousands.

Indispensable these are probably in the present state of the world, but we cannot avoid remembering for the time in human progress to come when such enormous masses of the wealth produced by human labour may not be diverted from its proper course in the comfort and necessities of man by brute force against the probability of brute violence or fraud.

The problem of invulnerability in ships of war to the direct stroke of a given maximum projectile, requires as its fundamental datum the dimensions and form, speed (for upon that depends the weight of engines and boilers), and equipment of the largest ship that is practicable and proper for the destined use. This, in our own case, finds its limit in the largest and longest ship of war that can berth at our marine arsenals and manoeuvre in our narrow channel seas—this last greatly depending
upon the smallness of circle within which "going about" can be performed. This circle rapidly enlarges with increase in length, the power of the rudder of given size to turn a given form of ship varying inversely as the fourth power of the length. These elements of the ship being settled, the question of defensive armour resists itself in the first instance into this—How shall the hull be arranged for forming the power, fuel, and equipment, so disposed over the required area of defended surface of hull, as to give, when reduced into a structure of iron and wood, or of any other material, the maximum resistance per unit of surface to the impact of shot at the greatest given velocity? It is well thus to state the problem with precision, as the ship yet to be built does not leave to any who treat of it a want of clearness as to its conditions and limits. The experiments made at vast expense, in this and other countries, have not advanced the great features of the question much beyond this, that no armour yet devised and capable of being borne by any ship of war afloat or designed, can withstand the stroke, a few times repeated about the same spot, of a projectile of 600 lbs. weight, with a velocity of under 2,000 feet per second. The only remarkable advance in resistance conferred by mere disposition of material of a given total weight, has been due to Mr. Chalmers' arrangement, in which the wood backing is divided and supported by transverse septa of plate iron. So far, however, it is clear that this is not likely to continue. The problem of the most powerful possible gun, like that of the armour, rests upon the data of the weight, form, and velocity of shot demanded; the latter element depending simply upon the weight of powder charge in relation to the weight of the shot. The form of the latter, and hence the calibre, which it determines, fixes the limit at which any increase of weight with a given velocity, or of velocity with a given weight, the gun, even though made of steel and wrought iron, our most resistant materials, and disposed in the best manner, in ringed structure, becomes crippled after a few rounds.

With rifled guns it is pretty certain that this limit is reached at a calibre not much exceeding 13 inches, and with a projectile of 600 lbs., propelled with a velocity of about 2,000 feet per second. Under these conditions every round produces some sensible deterioration of the gun; the metal of the interior tube, although of steel, becoming fissured first at the angles of the rifling growing over the sides of the powder and section of maximum strain, and the whole of the metal soon affording evidence of partial disintegration by simultaneous compression and tension in orthogonal directions in a plain transverse to the axis.

Rifled cannon are, however, not indispensable to the destruction of armour-plating, and it may be stated as certain that the value of each ship in war will increase with the range, accuracy, and extreme velocity, to effect punching through armour-plates, are the supposed advantage for marine use upon which those interested in the manufacture of rifled cannon have based their arguments for the preference to them over smooth bores through spherical projectiles. But accuracy and great range are all but useless in a cannon borne upon an oscillating deck, and of all conceivable ways in which a given amount of projectile power can be expended in penetrating armour-plating, punching out a round hole by an extreme velocity, having just the diameter of the shot and admitting of being easily plugged, is that which effects the smallest amount of permanent injury. A smashing shot by a ponderous projectile at a moderate velocity, which shall either stove in a large area of the ship's side at once, or shall produce a large irregular star of radiating fractures and detached pieces of plate, with shaken and damaged internal framing, is that which must produce the most "unmedicable wound" in any ship's side, and the one that may be followed up by "shell fire" from rifled guns with the most fatal effect. Such a blow may be delivered best by very large spherical shot with a moderate velocity. In such case the strain upon the gun is greatly reduced, not alone by the diminished initial velocity, but by the reduced inertia of the spherical shot in relation to the unit of area of the calibre of the gun. Moreover, the victory can be kept with the gun, and that an absolutely invulnerable armoured ship is an impossibility within the tonnage to which practical conditions limit it.

It is not a little remarkable, however, that, notwithstanding the great sums that have been expended in firing at armoured-plate targets at Shoeburyness and elsewhere, not a single satisfactory experiment has been made, with a view to fairly compare the destructive effects of rifle shot at great velocities with those of much heavier spherical shot at comparatively low ones.

Before leaving the subject of artillery, in which there is much of interest impossible to advert to here, I may mention that at present the well-known house of John Brown and Co., Limited, are at the expense of a large and complete set of experiments of "uses" or forge blocks, for making field guns, or even those of larger size, so as to avoid the evils incident to forging by the hammer—thus carrying out into practice that which was suggested by myself in 1855, in my treatise on the "Materials for the Construction of Ordnance." One of the consequences of this will be to greatly decrease the cost of production.

In iron shipbuilding there are no radical changes to note, but a steady improvement in the proportioning of parts is observable. The necessity of iron decks, in order to complete the upper member of the ship viewed as a hollow beam, is becoming admitted. The recent loss of the London will accelerate their introduction, inasmuch as iron decks admit of the construction of engine hatchway coamings in much stronger and safer ways than with wood decks and coamings. That all such hatchways ought to be fitted with that excellent form of self-releasing iron shutters known as the "butterfly coaming shutter," and that ventilation, to supply the furnace draught in the boiler room which is so often lost by way of wastage, may be provided by a concentric cylindrical casing surrounding the funnel with air space between, the loss of this ship proves; a lamentable form of demonstration that, however, was not needed by any of our best iron shipbuilders, whose desires are too often compelled to yield to the merely financial wishes of owners. It may be hoped that, after this catastrophe, Lloyd's rules will provide those requisites as indispensable to a seaworthy steam-ship. Iron hollow masts and yards are being largely adopted, partly recommended on mistaken mechanical principles, but mainly from their cheapness and the increasing difficulty alleged in procuring large timbers. Such hollow, and relatively very thin, but iron masts, will not be so subject to the elastic, or, it may be said, to the "bending" or "buckling" that weakens. As a result of their extreme stiffness, every variable or impulsive transverse strain, in place of being diffused and producing flexure over the entire length, and so easing the material, as in a wood mast, is transferred almost completely at once to the lowest point of the mast at the resisting fulcrum, and where the stress is necessarily greatest. If fracture occurs, it is, by the nature of the material, and of these conditions, at this point, and directly transverse. The iron mast thus presents scarcely any of the chances of temporary use or of refitment at sea possessed by the long splintering timber spar.

One of the effects of the extension and extending employment of steam in warship building is that not very distant future, will be the rapid increase in the total amount of the mercantile navies of the world. In the days of exclusively wooden shipping, the average life of a sea-going ship could not be taken at more than ten or twelve years (free from all casualties), but with proper original construction, and due care in preservation, it is almost possible to assign any limit to the life of an iron ship; and it will be far within the truth to say that each (casualties again apart) will last from four to five times as long as a ship of timber. The result must be the continual accumulation of mercantile shipping for many years, or perhaps decades, to come, and this cannot but be attended with great benefit to the world at large, in the diffusion of exotic commodities and the extension of trade and comforts.

I ought not to omit to notice the publication during the last year of the magnificent work of John Scott Russell, and of those of Mr. William Fairbairn and of Dr. Rankine, on shipbuilding, more especially of iron. The first of these works will ever mark an epoch in the literature of the subject.

The employment of twin screws for propulsion has, after slow and cautious trials, proved of great value, not only for the navigation of rivers and other shallow waters, and for affording the means of steam propulsion to the larger boats carried by ships of war, but, in the case of these, as they set upon their own length, a precious element in enabling an enemy's fire to be partially avoided. It may be proper to mention that in the two great mortar flats, designed by myself in 1864 for our own Government, and intended to carry the 36-inch mortars at Sebastopol and Cronstadt, twin screws were employed.

In the construction of marine engines, amidst many minor
novelties of improvements as to detail, the most noteworthy progress consists in the constantly accruing perfection in the use of higher pressure with expansion, and of improvement in steam and smoke. The immense advances that the feeding of the boilers with fresh water only affords. The employment of steel shafts and cranks, and all severely strained parts of marine engines (urged by myself some years since in an account of some experiments proving the relative weakness of large wrought iron, forged "tubes," read to the Institution of Locomotion and now recommended by marine engine makers) is now rapidly spreading. The greatly increased production of excellent steel, of various qualities and at a very reduced price (though still much too high) by the Bessemer process, facilitates this. The Bessemer converting process is now in extensive operation in several different parts of Europe, and is rapidly advancing towards the natural culmination, namely, that, except for special and exceptional purposes, wrought iron will become a thing of the past and be generally superseded by steel, a material weight for weight of much more than double the average resisting powers of wrought iron.

Much remains to be done by the physical experimentalist, however, before we can consider ourselves as having fully understood all the properties of this new material in constructive relations, and by the manufacturer to insure to his customer absolute metallic uniformity in the pieces he is called on to supply. Steel plates are already largely employed for shipbuilding, and its superiority on many points is being laid down to a very large extent. With steel rails and steel tyres the wear and tear of both is reduced to a mere fraction of that with those of wrought iron, and the co-efficient of traction sensibly reduced likewise.

The discovery of the oil springs in America, and the expiration of Young's patent for the production of somewhat similar oils by the distillation of coal at a low temperature, have given impetus to the endeavours of several experimentalists here, in America, and in the Continent, to adapt these oils as a liquid fuel for steam navigation. Many of the advantages alleged are real and well founded, and it can scarcely be doubted that to the greater safety and perfect combustion in marine boilers of such fuel will be added, and will be adopted on a large scale for certain special purposes at least. Up to the present time, however, no method tried for burning these oils in marine or other large boilers has met the conditions required to be fulfilled.

The increased tonnage and length of iron ships, and their far-unpreventable tendency to foul at sea, and still more in harbour, and most of all in the warmer latitudes, have produced the necessity for graving docks on many foreign stations. For structures of this character, always costly and in tideless seas expensive to work, floating docks built of iron have been substituted with great advantage in many cases, and the great dread of those have been produced by Mssrs. Rennie, of London and Deptford, for the Spanish and other Governments.

As regards direct improvements or changes in construction of steam engines for land use, there is not much of importance to notice. The applications, however, of steam power become day by day more universal and varied, as well as powerful. Steam ploughing, as well as steam traction on common roads, may be said to have become practically established and in use, although the short-sighted prejudices of landowners and local authorities have done their best to retard these beneficent substitutions of elemental for animal power. In both these classes of machinery, moreover, there is now but the first, the preliminary stage. The advantages of these have been found competent to ascend with facility, certainty, and sufficient economy, gradients the most severe that are necessary to ascend the crest of the Alps. Adapted to this principle, a railway is being now laid over the crest of Mont Cenis, to unite Bardoneche and Modane, on the Italian and French sides of the mountain, through a tunnel over one mile in length, the passage of Mont Cenis is simultaneously being out. This great tunnel, although advancing at a rapid and satisfactory rate per day, is not likely to be perforated through and the rails ready for traffic for probably five to seven years at least, and in this interval it is expected that the supra-montane railway will have returned a revenue large enough for the support of all the competitors. Sharp inclines have been at all times, but increasingly of late years, more courageously employed by Continental engineers than by those of our own country, where, indeed, the natural features of our islands do not present the same necessity
for sharp gradients. The Gövi and Sömmering inclines at an early period called forth, through the skill of Borowiec and several others, locomotives of before unknown weight, adhesion, and power; but even these have gradually given place to engines of still greater evaporative power, and so placed upon their wheels as to give effects weight in the adhesion.

The latest of these is the engine designed by M. Thonvenot (for certain Swiss railways), which may be viewed as two locomotives applied end to end at the fire-boxes, which are thrown into one greatly enlarged, and fed at the sides. These engines will weigh 80 tons, and in size and weight far exceed those now used in the North-Eastern part of France. Into the details of this engine we cannot go; it proposes several advantages, some of which are real, in addition to great evaporative power and great and uniform adhesion, but its effects on any ordinary rail will be damaging, especially on curves.

Coal burning in locomotives has become universal, and although the coal supplied in France is generally inferior in quality to our own, the perfection of the combustion, and freedom from smoke or smell, are in advance of our general practice. A still further advance has been very recently made on one or two of the French lines, in the adaptation of the fire-box arrangements specially for consuming very small quantities of coal, with material waste. The results obtained are satisfactory, and of high importance in many parts of Europe, especially in such regions as Bohemia and Hungary, where the coal is tertiary (ignite in fact, though presented when dug out the aspect of good Newcastle coal), and yet stables to pieces and falls in places, is employed. Such dust is compressed in hot cast-iron moulds, and reconstituted into bricks, which are used as fuel in the steam vessels navigating the Thessai and Danube, &c.

Steel fire-boxes have been in several instances substituted for those of copper on the French railways, upon which, as well as upon our Indian railways, and upon some of our British lines, the Giffard injector has almost superseded the feed pump. The theory of this remarkable instrument has within the last year or two received striking advances at the hands of French and German engineers.

Explosions of locomotive boilers continue to occur every now and then, with suicidal fatal effects. These are, to our disgrace, very much confined to England, and result almost entirely from the systematic neglect of periodical proof of the boilers by water pressure, a matter compulsory abroad, and against which the irrational dicta of locomotive superintendents in England ought no longer to be tolerated. These accidents have resulted in three or four cases on some branches, circumstances, whereby mechanically induced change of form in such boilers aggravates the loss of substance locally by corrosion.

The Mont Cenis tunnel, to which I have already alluded, presents the first example upon a great scale of the successful application of power to the perforation of rock. The origination of the machinery directly employed is unquestionably due to an English engineer, the late Mr. Bartlett, while the special machinery by which the natural torrents descending from the flanks of Mont Cenis are made available to compress air, as the motive power and means of ventilation, are due to M.M. Sommellier, Grandiis, and Grattoni, the engineers now charged with this magnificent work. The success of these machines for jumping holes in rock, now some years proved, has since led to many others for like purposes, and to the admirable coal-cutting machinery, driven by compressed air, now at work both in the North of England and in South Wales. These machines, while relieving the coal-hewer of the most laborious part, if not the whole, of his dangerous and unwholesome task, effect an economy in the coal necessarily destroyed in getting, to the extent of at least five-sixths of the whole.

In connection with these fine instruments for quickening man's mastery over matter in its crudest and most resistant form, may be noticed the revival of the employment both for blast and for smelting, and the visit of the North West uplands, and the then new, improved methods of its manufacture, due to Colonel Lean, of the Austrian service. The superiority as a rendering agent in blast-furnace work and powder, and its advantages in some other respects, are now established facts, and its manufacture as an article of trade has once more become active. Some other new explosive agents with much less promise have been brought before engineers, amongst which are a new gunpowder, the oxidising agent in which is stated to be chiefly nitrate of barytes, and the formidable and hazardous nitroglycerine or blasting oil, now on sale in England.

In noticing the methods of tunnel cutting by machinery, I may not omit to notice the remarkable work of Herr Kelba and his co-workers in the substitution of the black-iron framing, &c., for the mass of timbering usually employed in tunnelling operations. Nor, as being works highly analogous, and occasionally full of difficulties requiring to be overcome, can I pass the beauty of the methods, and the success with which vertical shaft-sinking, whether for collery or other purposes, has been achieved in accordance with Herr Kelba's patent. The successful methods of M. Guibal for sinking through running quicksand without air pressure, or pumping out the water, are worthy of all attention.

Tunnelling in water-bearing strata, as beneath the beds of rivers or estuaries, which received a shock from the disasters of the Thames tunnel, and through tunneling for many years, has once more resumed the position from which it ought never to have been displaced by the wholly exceptional conditions in which the elder Brunel placed himself. The Thames tunnel was, in fact, bored not so much beneath as through the Thames, for it was in some places but four feet below the bed, the latter being of mud almost as liquid as cream. Why this disastrously high level was chosen we need not now go into. If, however, the level of a tunnel be so fixed as to leave an abundant thickness of covering material above it, the work in reality presents no conditions different, or more difficult to cope with by well-known means, than those constantly met with in every land tunnel through a hill of water-bearing beds, the water supply of which may be practically inexhaustible, as for instance was the case at the Kilsby tunnel, on the London and Birmingham Railway.

And in accordance with this view I may mention, that a leader whose practical ability is justly valued in our profession, my friend Mr. Hawkesworth, has recorded his readiness to undertake a new tunnel under the Thames, and has expressed to myself personally his unhesitating willingness to undertake one beneath the Straits of Dover, and I should not be surprised if in the progress of events he may yet live to be called upon to do so.

And finally, and wholly independently, in the case of tunnels running beneath rivers or arms of the sea, has also been matured since Brunel's early day, in which the work is done in segments from above, and partly by coffer-damming, or the sinking of iron caissons. This admits of placing the level of the roof of the tunnel actually no lower than the bed of the river. This method has been pursued along the Mere and the Mersey, and it is at this moment in active operation in London for passing the new tunnel that is to carry the pneumatic dispatch railway from the Waterloo station south of the Thames, to the northern side at Whitehall, under the direction of Mr. Rammell, C.E.

(Suggestions to Young Architects.

At the meeting of the Architectural Association held on the 18th May, a paper was read by Mr. B. Ferry, F.S.A., containing "Suggestions to Young Architects for facilitating their correspondence with Chartered or Diocesan Church Building Societies, and Hints on some Practical Points.""

Mr. Ferry detailed the steps which should be taken to obtain aid from the various societies established to assist in the building of new churches or enlargement of existing fabrics, and explained the nature of the rules and conditions under which such aid was to be obtained. Glancing, then, to the works themselves, he deprecated the tendency exhibited in some directions to run up churches with the meretricious aid of the iron-founder. He was in favour of a sensible and severe form, adapted to the site and the aspect, and for exemplars he recommended the student of architecture to visit the North-Eastern part of England, and there to see in the way of parish churches. Solidity of construction ought to be kept in view as much as possible, for without it it was impossible to obtain that impressive effect which ought to be the first characteristic of a building dedicated to God. It was, he thought, a reproach to an age in which thousands of pounds could be readily obtained to underwrite any utilitarian object, that raising money for the building of churches should be a matter of so much difficulty. It was, in fact, a national
reproach that architects should so often be asked to prepare designs for "cheap churches." It was, however, due to the committee of the Church-Building Society to state that they were anxious in all instances to obtain fabrics of a church-like character; the first consideration being accommodation for the service of God and the people. The higher the tower and ornamental details to be completed out of funds to be provided hereafter. It was to their credit, also, that they were anxious to preserve old work as much as possible, and not to pull down or change any features of a building which marked the personal character to which it belonged. Many fine old parish churches had been pulled down in consequence of the ignorance of the professional adviser. A notable instance of such destruction had lately occurred in the county of Middlesex, where a fine old parish church, of great architectural beauty, which might have been restored with the best effect, and preserved for centuries to come, had been immolated to the ignorance of the persons who had the direction of the matter. Many hideous-looking churches and chapels had also been "put up" by local builders, no architect having been employed to give designs or superintend the construction. Some practical information of great value might be gathered upon these points by the study of the paper printed by the Royal Institute of British Architects in reference to them, and he recommended all young architects to take the advice given. Referring next to the manner in which the walls and roofs of buildings should be constructed, Mr. Ferry pointed out the necessity of choosing the most eligible site, so as to avoid land-springs in the foundations, and to get as much protection against the worst wind, without being accompanied by continuous rain, which would soak almost any wall exposed to their combined influences. In making foundations in clay soils, he recommended the free use of concrete rather than very deep foundations. He would advise, to insure solidity and provide against damp, to lay down a platform or bed of concrete, which exposed parts of the best kind, with the best wind and water, and the circumstance that in so many old parish churches the south-west walls were found to be plastered, arose from the circumstance that a driving rain of many hours' duration would generally find its way through, no matter of what materials the walls might be constructed. In order to prevent this, he recommended an inner lining of brick or slate, with an interstice between, which would be found to keep the interior face of the wall dry in any weather. The roofing of churches was also a point deserving the utmost care. Panelled roofs were the best, not only for the comfort of the worshippers, but also for the conveyance of sound; but, in cases where there might be no such advantage, he recommended that attention should be paid to ventilation, and sufficient draught secured to prevent the accumulation of moisture upon the beams. This moisture often fell in drops upon the pews, and, independently of the inconvenience, did much damage to woodwork of the best kind. Another subject the author brought under notice as deserving the attention of the architect, was the manner of laying encaustic tiles now so generally used in ecclesiastical structures. Great care should be taken in preparing the surface before laying the tiles, so as to prevent the use of unsacked lime. Many instances had occurred in which the tiles were broken and the flooring destroyed by the expansion of particles of unsacked lime. With regard to bells, now that steel bells were coming so much into use, owing to their cheapness when compared with those constructed of ordinary bell-metal, he recommended that in no case should the supports of the bells be made to rest upon any portion of the tower in which the bells hung, as the expansion of the metal was destructive of masonry. The caging of timber or machinery upon which the bells rested should be altogether independent of the tower. The neglect of this precaution often did immense injury to this portion of the building. Moreover, it was well known that those who had paid attention to the matter, that the tower of the church was far more certain to be injured, than the church itself, if the masonry by which they were supported was altogether unconnected with the solid masonry of the building. With reference to the new system, Mr. Ferry commented upon the evils of unendowed or proprietary churches, which, he said, necessarily led to the total exclusion of the poor, because the income of the incumbent and the expenses incidental to maintaining the services of the church had to come out of whatever funds were obtained from the letting of the seats. Architects had, he thought, reason to deprecate the pew system, with all its abominations. Mr. Ferry concluded his paper with some practical hints on the building of parsonage-houses, explaining the equitable nature of the arrangements for assistance made by the Commissioners of Queen Anne's bounty. No sum greater than three years' value of a living or benefice was advanced; but the payment was extended over fifty-three years, with thirty-one years' time the property, which no change of occupier could affect. By this means the occupier for the time being was in no case bound to contribute a share to the burden beyond that for which he obtained full value.

INSTITUTION OF CIVIL ENGINEERS.

May 15, 1868.—The discussion upon Mr. Burnell's paper "On the Water Supply of the City of Paris," occupied the whole evening.

After the meeting, Mr. H. Temple Humphreys, Asso. Inst. C. E., exhibited and explained, with diagrams, an instrument called the Cyclooscope, for setting out railway or other curves, without the aid of the transit theodolite, &c. Externally, it somewhat resembled a box sextant. It was composed of two essential parts only, viz.: two plane discs, or cross-springs, ready for use. One of these springs, the other over one-half of its surface. By a law of physical optics, which was called either combined or successive reflections, a series of images would be formed in the half mirror, which were rendered available to set out any curve of any given radius, by simply moving the eye to the projection of a point at the same time setting the two mirrors at an angle to one another equal to the required tangential angle. Then the several successive reflected images of a ranging rod, for instance, were seen to lie upon the projection of a point at the radius of the circle of a point, and exactly set out in the field by simply placing other ranging rods in line with these several images. This could be done by looking through the unaltered half of the half-mirror, and placing the rods opposite to and overlapping the other, or by making a lens in the mirror, and the whole process of setting out a true curve was shortened and simplified. After setting the mirrors to the requisite tangential angle, no further adjustment or support was needed than could be afforded by the top of a ranging rod placed at the commencement of the curve, and shifted occasionally to any stake on the curve that the limits of distinct vision might require.

Cork Springs.—In a recent report upon new mechanical applications the secretary of the Franklin Institute called attention to the use of cork in place of india rubber, as a support for freight cars and like heavy vehicles. One would not be led by any means to predict the efficiency of cork in this connection, from ordinary impressions of its properties. The dealings with the properties of the cork are harsh, hard, and full of fissures. It is cut into disks of about eight inches diameter, each pierced with a central hole. Previous, however, to cutting it, it is soaked in a mixture of molasses and water, which gives it some softness and renders it permanently moist. A number of these cork disks are placed in a cylindrical cast iron box, a flat iron lid or disk is placed over them, and by hydraulic pressure is forced down so as to reduce the thickness to one-half. A bolt is then run through box, corks, and cover at the centre, and a nut being screwed on this, holds all in place, when the press is relieved, and the box of compressed cork, or cork-spring is removed. A spring is placed in a testing machine, under a weight of 20,000lbs., shows an elasticity suggestive of compressed air in a condensing pump. One would expect, from the appearance of the material, that under heavy pressure, it would be pulverized or split into shreds, especially if this pressure was assisted by violent shocks; but even so much action takes place. A pressure which destroys india rubber, causing it to split up and lose its elasticity, leaves the cork unimpaired, and, with the machinery in use, it has even been impossible, with any pressure attainable, to injure the cork, even when areas of but one inch were acted upon. In connection with this subject, the President, Mr. Wm. Sellers, succeeded, at the conclusion of the discourse, to mention that he had for some five years, employed a forging machine in which a spring of the form and material above described was used and subjected to continual and violent shocks, and that its performance had been most thoroughly satisfactory, with no signs of deterioration.
The strength of wrought iron in extension and in compression is about the same, yet the bottom of the ship is usually made enormously stronger than the top.

Some iron ships, indeed, have no proper top, or only a wooden one. Much of the strength of the bottom, which might otherwise be made available in giving strength to the ship, considered as a floating girder, is thus wasted.

I indulge the hope that the economical considerations pointed out may be not only useful in lightening and strengthening ships designed for war, but in inducing private shipbuilders to introduce partial iron decks so formed into ships designed for commerce. I may add, that these proposals do not form the subject of any patent.

GRAVESTONES.*

By the REV. E. L. CUTTS, M.A.

Let us first take a rapid glance at the Mediæval gravestones, to which we naturally look for models, or at least for suggestions, for our own practice; and first of all we may notice that the Mediæval gravestones seem to be modifications of Classical ones. The old Etruscan sarcophagi continued to be used by Christians, and was gradually diminished in size and modified in form, till it took the shape of the tapering stone coffin with its coped lid. A sarcophagus of Classic shape, Romano-Gallic, with Christian symbols, from France, shows the transition from the Classic to the Mediæval form. The ordinary head-stone, with a cross that is deeply carved, has its origin in the Greek and Roman gravestones. On Etruscan sarcophagi we commonly find reclinings effigies of very elegant design, which perhaps suggested the Mediæval effigies, though the attitude and spirit of the figures are very different.

The rude upright unhewn stone, of earlier than Classical times, is found in the form of the grave stone which was first marked with a small cross; then the head was rudely worked into a cross shape; and so it came to be developed into a finished cross, like the Runic or Saxons crosses, and still later into the elegant Mediæval churchyard cross. When we put together the ancient examples which exist in the British Islands, we see a very large number of all the kinds which I have mentioned, and extending in date from Roman times downwards.

But there is another kind of monument more ancient, more appropriate, and more universal than all the rest, viz., the earthen mound. These were the monuments of heroes in the days of Troy, and Thersites and Hector were buried there. They are dotted like low natural hills over the Steppes of Tartary; they are found buried under the rank tropical vegetation of Central America, monuments of races of whom no other monument remains. In England all the races who have successively inhabited the land have left those monuments behind. The British burrows in Saxon times, the 'great camp,' and the Roman tumuli, erected over sepulchral chambers, and th: Saxons barrows, in which we find the remains of whole families, the men with their rusty spear-heads and swords lying by the bones, the women with their gold-engarneled ornaments mingled with their dust; and the low turf mounds, which the sexton heaps with his spade over the humble graves in our country churchyards, are the undoubted successors and representatives of the barrows of our Saxon forefathers. Until a recent period the people were buried in them unclothed, as their forefathers were. After all, it is the most appropriate monument. It tells us that 'there one of our fellow-men has been laid in the ground.' It is a silent witness, just that length and breadth of kindred dust which you see raised above the general level of the earth; that heap of dust is his effigies, for dust he was; the green grass which will grow over it will be his symbolic epitaph. — As for man, his days are as grass.

In England these grave-mounds are always of the low rounded shape, with which we are all familiar. In Normandy I have seen grave-mounds shaped in imitation of a ridged coffin-stone, and sometimes with a strip of turf raised from end to end and side to side in imitation of the cross upon a coffin-stone. The old types of monument which have been chiefly imitated in our modern Gothic gravestones are the recumbent stone, which we commonly call a coffin-stone, the upright head-cross, and the sarcophagus. Let us glance at the chief peculiarities of these ancient gravestones. The coffin-stones are usually long, narrow and tapering from head to foot, and probably always formed the actual lid of the stone coffin in which the deceased was buried: the coffin was sunk till its upper margin was level with the earth, and then the lid formed his monument. Sometimes the lid is flat, sometimes it is copped, as if to throw off the rain. In nineteen cases out of twenty there is a cross carved upon the coffin-stone. When the stone is flat, the cross is sometimes only outlined with bold incised lines; sometimes it is sculptured in low relief. There is seldom an inscription, and then little more than a name; but there is often a symbol of the calling of the deceased sculptured beside the cross. The cross itself was the symbol of the Christian person: when two persons, or man and woman, were buried under two coffins, in one case a little cross is added, perhaps the symbol of a child. The symbol of calling was placed beside the cross: a sword for a knight, a chalice for a priest, a bow and arrow for a forester, and a pair of shears or scissors for a woman. There is one symbol frequently found attached to the middle of the shaft of the cross whose meaning has baffled all our ingenuity. It is something like a bracket on each side of the shaft; sometimes the lines are headed like those of a riband; sometimes they are stiff, as if of stone or metal, and they differ a little in shape. There is one at Horningsea, Cambridgeshire, and others at Helstone, Peterborough; they are very common. There is a silver ornament on a Roman gravestone engraved in Montefaucon.

The thing that most strikes us, perhaps, is looking over a collection of drawings of these coffin-stones, is the endless variety of ingenious, fanciful, beautiful cruciform designs upon them. Among them are some examples of a method of counter-sinking the design in a way which gives it the appearance of being dug out from wear, and often adds considerably to its effect by enclosing it in a kind of frame.

After looking over a collection of drawings of old designs, it would seem to be the easiest thing possible to reproduce them, or to design modern ones in the same spirit; but if we look through a series of drawings of modern designs, we shall see that the attempt to reproduce an ancient design generally fails somehow to retain the simplicity and breadth and vigour of the old one; and the attempts to design new ones in the spirit of the old are, I venture very humbly to say, too often unsatisfactory, a sort of gracelessness, superfluity of ornament.

These, perhaps, are some of the reasons of failure —

The first, I think, is the shape. There is something picturesque in the long, narrow, tapering coffin-stone; but it derived that shape from the fact that it formed the lid of the stone coffin. When we lay it over one of our modern graves it is inappropriate, for it is not the grave over which it is placed, and it is not large enough — wide enough — to cover it. It is a coffin-lid without any coffin under it; it is a gravestone which is too scanty to serve its purpose of covering the grave.

But, finally, to remedy this defect, and to make the monument larger and more imposing, the coffin-stone in modern practice is often mounted on a massive slab of stone by way of base. But this introduces another incongruity. The massive slab is the real gravestone, and it should be dealt with accordingly. I do not think it is a happy idea to take a strait coffin-lid (the tapering shape irresistibly suggests the idea of a coffin-lid) and lay it upon the gravestone by way of monument. In the margin of a monument in the British Museum is a slab, with a horseman's pale horse, who carries a taper coffin-stone by way of a shield; to lay one on our gravestone is to use it similarly as a symbol.

A third source of failure, I think, is in the character of the designs sculptured upon the coffin-stones. If we compare the development and execution of Gothic and Romanesque or contemporary architectural sculpture, we shall find that, in the great majority of cases, the gravestones are comparatively simple in design and rude in execution. The design is generally bold and vigorous, often ingenious and beautiful; but, after all, it is simple, and it is only deeply scratched or rudely carved on the stone. I can imagine that the caligrapher or the calligrapher may have drew the design on a scrap of vellum, and the local mason hatched it out with his stone axe. The designer showed some taste in giving such a simple broad design as could be effectively executed by such rude hands, and the mason did his work well when he had cut it deeply, or hatched it in relief, with freedom and vigour. But when this kind of work is copied,

* From a paper read at the Architectural Museum.
with our modern elaborate precision, its vigour and spirit usually vanish, and leave nothing but a bald and tame result. When such a stone is mounted on a massive base, and protected perhaps by an elaborate iron screen, the poverty of the design is made more conspicuous by this sumptuous treatment.

I venture to suggest that the modern recumbent gravestone should be of regular oblong shape, the length of the stone equal to the size of the grave which it is to cover. The flat and the coped coffin-stones suggest two different styles of treatment. In the flat style, the size of the stone leaves ample room for an inscription round the margin, to be enclosed within marginal lines or mouldings. These will advantageously narrow the field of the stone, and upon this field may be written less of less. I think our modern taste requires for its satisfaction more elaboration of design and greater skill in execution than are found in the majority of these old coffin-stones; and now there is not the slightest difficulty in obtaining both. There are some of the old stones which possess these characters, executed probably where skilful design and workmanship were easily accessible. At Milton, Oxon, for example, there is a foliated cross in which the foliation is of the best style of Early English foliage. At Hexham, Northumberland, there is an incised slab in which the whole field of the stone is covered with a pattern of vine foliage. In Lincoln cloisters there is a thirteenth century stone which represents, "the vine of Jesse," very similar in design, and covering the field. The method of countersinking the design, shown in some of the exhibited examples, is worthy of consideration; and both in incised and countersunk work it may be considered whether the incisions may not be filled in with colouring matter, if any colouring matter will resist the weather; or filled in with coloured stone. If, again, this method of inlaying with stone and marble, if it will stand our climate, opens up a wide scope for elaboration in a style which has taken a strong hold of the present taste; only, again, I confess I have misgivings whether, except upon a very simple and careful use of it, it will stand our climate.

The coped stones suggest another mode of treatment. Let the stone still be rectangular in plan—not tapering; mould the edge deeply, leaving a plain fillet among the mouldings, broad enough to carry the inscription, and from the upper moulding carry up the plain ground, and make such a simple roll at the angles, to form a kind of cross. The tomb of William Rufus, in Winchester Cathedral, is something after this kind. One in the Temple Church has sculptured ornaments carried along the edges of the prism with very good effect. Or the mouldings may be made a little deeper, and a narrow flat top left for the reception of a cruciform slab, with perhaps a little decoration, the whole resembling the head of a cross, and a practice to add a head-cross and foot-stone to a crossed coffin-stone. This, I venture to think, is also a mistake. It is an unnecessary combination of two different monuments. Where there is a coffin-stone with cross and inscription, a head and footstone beside are unnecessary. If the ends are rather high, and it is adapted to be a headstone; and the gabled ends, or of which the clear block, and in the form of a head-cross, and it is desired to lay a stone over the grave to protect it, it should, I think, not be a regular coffin-stone, but a plain and simple stone, without any cruciform device. There are some examples, both in England and on the Continent, of a variety of the coped stone which I can best describe as being on the plan of the roof of a cross church. The ridges, with a bold roll on them, form a plain cross. It is a very beautiful design, susceptible of architectural moulding—dog-tooth, ball-flower, &c., the like in the base, and of cusping in the gabled ends. Some of the modern adaptations of this type are among the most successful modern designs I have met with.

I come now to the class of head-stones. There are two great types. In one, the general form of the stone is that of a cross; in the other, the stone has a rounded head, and a cruciform device is either incised or carved in relief upon the face of it. Very few of the examples of these two types of head-stones remain; there are hundreds of coffin-stones of head-stones to be seen everywhere. Our modern designs for head-stones are, I think, less satisfactory than the modern coffin-stones. This does not arise from the scarcity of ancient examples, for many of our cruciform designs on the flat stones are equally applicable, with a little adaptation, to head-stones; and the gabled stones, of which we have many fine examples, would also afford authorities easily dified to the purposes of design. It is the latter type which has chiefly been followed in modern designs, and the fault in them arises almost entirely from making the stone too large—too high, and too wide. The fault does not lie with the designer, but with his clients, who will insist upon having a stone large enough to contain a long inscription, or inscriptions, to several members of a family.

The more I have noticed of the few old head-stones which we have is, that they are small in size and very simple in character. In the modern adaptation of them, a cruciform head of proper size is put on the top of a high, wide slab, and the effect does not satisfy the eye. Many attempts have been made to shape the slab so as to make it a proper base for the cross which is to rest upon it, and the modern head-stones retain the proportions of the old ones, and look pretty well on paper; but when you see them executed you find that, though the old proportions are retained, they are magnified two or three fold, and that the result is the usual high, wide slab, with a cruciform head of much too large a size. In short, I have looked through a considerable number of modern designs, in which the designers have attempted to solve the problem, and I come to the conclusion that it is simply impossible to combine a high wide base with a cruciform head so as to produce a satisfactory result. We must, I think, try to persuade people to be satisfied with low and narrow head-stones. If such a stone seems too simple, and does not satisfy the desire to have something more sumptuous, perhaps we can arrange the matter by making the monument of marble and bestowing some carving upon it of a more artistic character than usual, i.e., give them the value of the money they insist on spending on art instead of material. The greatest difficulty, perhaps, will be to persuade people to be satisfied with anything but a very short, unostentatious inscription will spoil the effect of the design. We might, perhaps, obtain leave to have a proper head-stone if we put a flat stone behind it, on which an epitaph might be inscribed; only this stone must be low and narrow, and unostentatious, or it will spoil the effect of the headstone.

The other type of head-stone, in which the stone is cut into the form of a slender cross, does not seem to have been much followed in modern design; probably because it offers still less space than the other type for inscriptions; but I think it offers scope for variety of designs and uses. First, there is the usual grave cross. What we especially want in the monuments for our crowded cemeteries is great variety in their general form; and this class of crosses, ranging from a slender plain cross a foot high up to a tall cross of the ordinary "churchyard cross" kind, or even to a cross of the Eleanor Cross type, offers greater scope for variety of designs and uses, than the head-stone has.

Most of the ancient crosses of the head-cross type which remain to us are of early date, and of Saxon character. I have seen some of them reproduced in modern designs, and I do not think the result is satisfactory. I do not believe there is any great beauty to our eyes in the intricate interlaced work in which these crosses consist. But I think we appreciate the mystical meaning of the lacertine monsters which they used so commonly in ornamentation; and I doubt whether the peculiar outline which we find commonly associated with such ornamentation is that which our modern taste desires. Of course, some people take pleasure in the reproduction of these forms; or they would not reproduce them, but I think they must be an antiquarian pleasure derived from the associations which they awaken rather than from the intrinsic beauty of the designs.

The great majority of the tall crosses to which I have pointed as affording a suggestion for monumental crosses are of this early type. Of the steeple and churchyard crosses of Gothic design few have escaped mutilation; a stepped base and broken shaft may be seen in hundreds of our villages, but the head—the crown of the design—is almost always broken away. It is quite a wonder to me that, while people have been reviving everything else Gothic they have not revived those crosses. It is not the crosses which broke them down, it was the Puritans. Some of them may have had superstitious images upon them, and may have deserved to be broken down; but it is easy to restore them with a cross head, or with a sculptured group which has nothing to do with it. I am much too old to be very glad of all the old ones restored, or a new one erected in every churchyard. I do not know any small architectural work which is more beauti-
ful, and its significance and appropriateness as the ornament of the churchyard or cemetery are manifest.

In Saxony and other individuals of this kind might be erected, besides the one churchyard cross, it has to be considered how it would look to have several such crosses in the same churchyard. If they were not too numerous, and if they were sufficiently varied in general size and form, there would be no fear. There are two at Penrith of the same size and design, at the head and foot of a long space, enclosed by very ancient semicircular stones, called the Giant's Grave; they do not spoil one another. There are two at Sandbach, Cheshire, in the market-place, so close together that their bases touch one another; they are of different size and design, though of similar date and character, and they form a very picturesque group. In MS. illumination we sometimes find that the four tall monumental crosses represented in the same churchyard. The churchyard cross would be distinguished from sepulchral monuments of the same type by being placed on a base of steps; and it might easily have a further pre-eminence given it by the style of its design or subject of its sculpture. It might have a religious significance indicated by the use of the arcade, and the niche for the patron saint in a canopied niche on its shaft. The monumental crosses would, I suppose, not have the same spreading octagonal graduated base, but would rise from a base which covered the grave, and that base would afford ample space for a suitable epitaph.

Another very common form of modern monument is the high tomb: it does not seem to have been used as an outdoor monument in Mediaeval times; but now-a-days it offers the supposed advantage of a more imposing and sumptuous monument than a mere coffin-stone or head-cross, and is therefore popular. Some of the modern designs are adopted from the old sarcofagus. The old sarcofagus, hewn out of one stone, was a very massive and imposing monument, and derived solemnity from the fact that it actually contained the body of the deceased. Some of the modern designs have the modified form of a Mediaeval shrine. But a modern high tomb, which is built up of several stories, is, I suppose, far more to be desired than its mediaeval prototype.

The body lies in a grave beneath, and the interior of this sham sarcofagus or shrine is empty. In a working drawing for one which I saw the other day there was this observation written on the side: "The tombs, for one thing, cannot be filled with rubbish;" "brickbats, I suppose, and fragments of stone—a convenient way of getting rid of the mason's débris, and calculated, I think, to illustrate the inappropriateness of the kind of monument.

Sometimes the high tomb is a copy of the Mediaeval altar tomb, or a modification of it. I suppose, the body was contained within the tomb, and masses for the soul were offered upon its top, so that it is doubly inappropriate for modern use. These objections to the high tomb may, however, be easily removed by not enclosing the space beneath the top, whether the top be flat or coped, i.e. by mounting the top on columns, or by piercing the enclosing sides in panels, so as to show that it is only a monumental slab mounted on an architectural base.

Since variety of type is a great desideratum, I will suggest one of these table tombs, with a square tester over it; there are two in Aston churchyard, Cheshire, with effigies lying on the high tomb, which seem to have been sufficiently protected from the weather by the broad ogee canopy.

Perhaps the greatest difficulty the designer has to contend with in getting monuments that shall look effective is, that the monument is regarded on the one hand as in competition with the church and cemeteries, that they make the place look like a stonemason's yard, and the designs ruin one another. This crowded appearance is exaggerated by the unnecessary size of all our monuments—coffin-stones on massive bases, head-stones three times as high and broad as they should be, and other types of monument on a large scale. In the designing of the monuments we less, we should get more greenward, which is what is wanted as a setting for the pieces of architecture.

We may often obtain a broader foil of green, and a more complete isolation from neighbouring monuments, by judicious planting of shrubs and trees. A better effect for our own monument, and for its neighbours also, may often be got by designing the monument with reference to the place it has to occupy. If there are many head-stones about the place, a flat gravestone will look out of place. The same is true of a churchyard where individual monuments are too small, and the churchyard itself is only too crowded already with both coffin-stones and headstones, a slender head-cross may be relieved against their broader forms, or a short massive cross, like that at St. Buryan, will assert itself by its solidity, or a tall churchyard cross will make itself conspicuous. The best effect of all would be obtained if the churchyard were built up one on the other, and all the rest would be content with plain turfed grave-mounds.

What do we want any other monument for? Partly as a lengthening out of the last and offices of affection—a doing something more to show our love and regret; partly, I suppose, to ensure the grave from violation, partly to form a more permanent record of the place to the world, and partly because affection may from time to time be paid; partly it is to keep the memory of the lost one alive a little longer among men.

To preserve the grave from violation—a very natural feeling, and yet, alas! how vain the attempt. Go into any village churchyard and look round you. All the generations of the Champernels and Despots, all the first Saxon settlers down through 1,300 years to the fathers of the present generation, have been buried in that churchyard. How could you preserve their graves from what you call "violation?" And, if you could, why should their graves be preserved from "violation?" They have been preserved from the fire of the scythes and the hoe, and a fresh crop of spring corn is at this moment growing upon them by other hands. They passed away from the houses which they built, and others' children are now cradled within the old walls. And so their dust was mingled with the earth of the churchyard, and successive generations have been laid over and over again on the same graves until their dust is indistinguishably commingled. You cannot preserve them from violation.

But you want to mark permanently the place where your own dead lie, and to keep their memory alive among men. Well, it might be cynical to say that your own memory ought to be yourself sufficient remembrance of your dead, and that you will strive in vain to make the stone remember them unless they have themselves done something to be remembered for. At any rate, a gravestone will not serve the purpose very long.

What has become of all the old gravestones? In pulling down old churches, to rebuild or repair them, we often find a churchyard full of them built up in the old walls, as at Bakewell, the Domesday and Hospitium Hiberna. And, depending upon it, our monuments will no more remain inviolate than those did, and may chance to be put to much viler uses. Why, if everybody's grave had been kept inviolate, and everybody's friends had put up a stone monument to perpetuate his memory, there soon could not have been fields left for men to grow their corn and pasture their cattle upon, and mountains would have been levelled for monuments, and the face of the whole earth would have been crowded with monumental lumber. Let us be satisfied to have our dust mingled, confused, lost, amidst the dust of our fellow men, there will be nothing wanting of us at the resurrection: let us be content to have our memories fade out of remembrance in the world, if only our names are written in the Book of Life.

INCRUSTATION IN MARINE BOILERS*

By P. JENSEN.

The question of keeping marine boilers free from deposit or incrustation has for many years been one of the most prominent before the profession; in fact, ever since the first steamer entered sea-water, and it is still very worthy of our close attention. It presents itself to us principally in three distinct forms, viz., safety against explosions, economy of fuel, and durability of the boiler itself. All know that sea-water causes incrustation and corrosion when boiled in a close vessel, i.e., in a steam boiler. It is also known that, in the question of internal corrosion of marine boilers, though closely connected with the subject before us, for fear of extending the length of this paper; but, we may, in passing, note the fact that internal corrosion below the water-line in a boiler does take place, and that the scale thus formed is not where the scale has been removed; but that otherwise this scale, so injurious when allowed to accumulate to any thickness, acts the part of a shield or protector to the plates of the boiler against the action of the sea-water. It is also contained in the water, of which the weight of saligna is by far the most destructive, though happily, the smallest in quantity. And here the author may be allowed to call the attention of the meeting.

* Read before the Society of Engineers.
to an excellent paper "On the Wear and Tear of Boilers," read before the Society of Arts, in 1855, by Mr. F. A. Paget, who treats the subject of corrosion of boilers very fully. In the ordinary practice of sea-going steamers with common condensers the feed-water is drawn from the hold of the vessel and thence forced through a number of small iron pipes; and the hot water condensed was sometimes collected, and even returned to the boiler. The water was then subjected to various degrees of corrosion by the iron pipes and other parts of the apparatus. The process is, of course, very slow, and the corrosion due to this cause is negligible compared with that due to other causes, such as the presence of impurities in the water, the action of the water on the lining of the boiler, and the action of the fuel. The corrosion due to the iron pipes is usually neglected, and the effect of the water on the lining of the boiler is considered to be negligible.

In the case of a steam boiler, the water is first heated in the firebox, and then passed through a series of tubes, where it is further heated until it reaches the desired temperature. The water then passes through the superheater, where it is further heated, and then through the economizer, where it is heated again, before entering the drum. The water then passes through the boiler, where it is heated again, and finally enters the steam chest, where it is further heated, before entering the steam space.

The water contained in the boiler is believed to be mechanically present in the pores of the scale, and not chemically dissolved. Of course marine boilers are scaled off as often as they can be done, but for long voyages it is often out of question. Starting with 20thlb. pressure in the boiler, and clean fires, is generally found that, on the second or third day, in spite of greater exertions of the stokers and harder firing, only 1/10th., or less, can be kept constantly, and this loss in efficiency goes on at an increasing rate. In eight days' constant steaming it has been found (in one instance) that, starting with 21st., the working pressure was reduced to 16th. at the end of the voyage, this, it is supposed, without all at forcing the firing. Take another instance, at random, the Persia log, from year 1855, September 20th to October 9th, inclusive.—Total number of crossings: 91. Total tons of water consumed: 1,402 tons. But whereas the consumption of coal per hour per indicated horse-power was 3.9 to 3.96 on 30th September (it left New York on the 29th), it had increased to 4.3-4.16 on the 8th of October. (Ariettes, May, 1860.) These few items illustrate sufficiently the well known fact that corrosive scale, even only as thick as paper, has a very great and perceptible influence, tending to counteract the economy of the fuel.

As to durability, marine boilers, with all care, on an average only last five years; but this is chiefly owing to internal and external corrosion, rendered more intense by the salts contained in sea-water, which, besides, promote galvanic action in various ways. This must be understood to apply to boilers properly managed, that is to say, in such a way that only a very thin scale is allowed to be formed; for, as mentioned above, if thick scale is formed anywhere in places exposed to the heat of the furnace or the escaping gases, this circumstance contributes directly to the burning away or oxidizing of the plates. This fact, that marine boilers wear out so quickly, must, as far as can be seen at present, remain unaltered so long as salt water is employed, and in spite of repeated trials, and more or less success in surface condensing, still we are far from the general introduction of surface condensation; and, considering the vast number of marine engines in existence worked with condensing power, the condenser is as unsuitable as the boiler of the same period under consideration is left intact. It is now proposed to give a general explanation of the action of sea-water as it obtains in the marine boiler. The specific gravity of sea-water varies according to different localities; and calling that of pure distilled water 1,000, the average specific gravity of sea-water, according to Faraday, is 1,027.

For sea-water of the specific gravity of 1,027, such as he used in his experiments, one cubic foot weighs 643.16 lb. or 1,026 lb. onavoirdupois, and contains of

| Chloride of sodium, or common salt. | 23.785 |
| Fatty of magnesia. | 3.763 |
| Sulphate of magnesia. | 1.215 |
| Sulphate of lime. | 0.013 |
| Total. | 31.930 |

besides small quantities of other salts, but too minute to be of any consequence.

Dr. Ure found the largest proportion of salt held in solution, in the open sea, to be 38 parts of 1,000, and the smallest 33; the Red Sea, however, contains 35 parts in 1,000; the Baltic contains 9; the Black Sea, 21; the Arctic Ocean, 28; the British Channel, 39; and the Mediterranean, 39.

The following table shows the boiling point of a mixture of different waters of different densities at a barometric height of 30in. of Mercury:

| Boiling point of water | 214.3 |
| Point of freezing | 214.3 |
| Specific gravity | 1.056 |
| Pure water | 215.3 |
| Common salt water | 216.3 |

The deposit of salt begins at a density of 30, and at 30.8 we arrive at the point of saturation, or the point at which water is incapable of dissolving any more salt. According to M. Courté, an imperial gallon of water is capable of holding in solution, at 60 deg. Fah., and at boiling point, viz., in the open air, the following weights, nearly:

| Carbohydrate of lime | 12 grains |
| Silica | 14 grains |
| Sulphate of lime | 32 grains |
| Carbonate of magnesia | 32 grains |
| Sulphate of potassium | 10 grains |
| Sulphate of soda | 8 grains |
| Chloride of magnesia | 28 grains |
| Nitrate of lime | 8 grains |
| Chloride of lime | 64 grains |

The order of decomposition in the boiler as the water becomes concentrated is:

1st. carbonate of lime; 2nd, sulphate of lime; 3rd, the salts of iron and oxides, and some of those of magnesia; 4th, silica or alumina usually with more or less of organic matter; and 5th, chloride of soda or

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common salt. Now it is well known that sulphate of lime is the worst of all the salts in a marine boiler. We have seen that 37 or 37 in 100, is the point of saturation for common salt, but in the case of sea-water which contains other salts besides, 36 parts in 100 saturation at 226 deg., and 30 in a hundred at 238 deg. Now, taking 20,0 lb. pressure, which is the most prevailing now, there is a saturation of 37. This is a reduction of 1-2 deg. per $\gamma$, according to Professor Rankine, corresponds to a temperature of any 262-9 deg. Fab. How much salt can be held in solution at that temperature is not known to the author, but it is well known that the quantity decreases with increased temperature, and this is the reason of our not having yet arrived much beyond 200 lb. pressure in marine boilers working with salt water. In marine boilers we have chiefly to do with sulphate of lime, the proportion of the same so largely preponderates in the incrustation on analysis. As to calcium sulphate, this enemy to boilers is fortunately not a constituent of salt water, except in the Mediterranean, which contains a trace of it (901 in 100 parts).

Sulphate of lime forms deposits at all temperatures and all densities. Salt, on the contrary, forms deposits, as we have seen in the foregoing, not to any extent except when in the quantity of $\gamma$ or $\gamma$, the quantity of the same required for saturation decreasing with increased temperature, and the amount of deposit that will take place long before the point of saturation having been arrived at, increasing with increased temperature or pressure. Sulphate of lime will deposit at any temperature; but it so happens that increase of temperature also increases the amount of deposit. According to M. Biot, for water at 300 deg. the stability of sulphate of lime at different temperatures is as follows. The table indicates the solubility for different temperatures, as well as degrees of concentration at which the saturation of sulphate of lime takes place:

<table>
<thead>
<tr>
<th>Degrees of air</th>
<th>Temperature</th>
<th>Solubility or</th>
<th>Total pressure in</th>
<th>Sulphate of</th>
<th>Sulphate of lime in</th>
<th>Sulphate of lime in</th>
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<tbody>
<tr>
<td>124</td>
<td>217-4</td>
<td>500</td>
<td>105-00</td>
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<td>13</td>
<td>218-6</td>
<td>548</td>
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<td>11</td>
<td>218-6</td>
<td>603</td>
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<td>10</td>
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<tr>
<td>9</td>
<td>220-6</td>
<td>733</td>
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<tr>
<td>8</td>
<td>221-6</td>
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<td>7</td>
<td>222-6</td>
<td>863</td>
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<td>6</td>
<td>223-6</td>
<td>928</td>
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<td>5</td>
<td>224-6</td>
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<td>225-6</td>
<td>1058</td>
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<td>3</td>
<td>226-6</td>
<td>1123</td>
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<td>2</td>
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<td>228-6</td>
<td>1253</td>
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<td>9</td>
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Now this table, and that of the amount of salt which can be held in solution at high pressure, say 20 lb.—a table, the author believes not to be found anywhere—would give us, as near as possible the quantity of water that ought to be blown out of a boiler to prevent, 1st, accumulation of salt in the tubes, 2nd, formation of incrustation of sulphate of lime, in any quantity injurious to the boiler in any high degree. True, there is one way of getting over the difficulty, viz., working with a lower pressure, but this is out of the question for several reasons, and we must hence use experience and experiments as our guide. From the foregoing it will be clear that every pressure requires a different treatment and a different amount of water to be blown off. If we blow off more than is necessary to prevent accumulation of salt in the boiler, we have to pump a greater quantity of feed-water in, and consequently a great amount of sulphate of lime in solution, which will be deposited as a hard, tenacious scale. On the other hand, if we blow off too little, we will certainly get less sulphate of lime, but the accumulation of common salt will ultimately choke the passages in the boiler. This maxum, though true in theory, is modified in practice because of the more or less rapid circulation of the water. To strike the just balance it is, as before said, necessary to be guided by experience. It seems that ignorance has prevailed in high quarters till very late years because of want of data, on which was based M. J. B. Napier's paper in 1859, before the Institution of Engineers of Scotland, in which he recommended the use of a much larger regenerator (a sort of tubular feed-water heater, the heat of the brine blown off being made use of for that purpose), to blow off to a greater extent. He tried the experiment himself, and gave the results in a paper, read February 17th, 1854, before the same institution. For the screw steamer Lancefield, trading regularly between Glasgow and the Hebrides, he made regular regenerators, and blew off the condenser once at sea, and the results were such as to keep the density of the water in the boiler at very nearly the same point as the water in the sea. After a week's running, the boiler was examined, and instead of its being clean and free from scale, he found, to his surprise, it was coated with a much thicker scale than under usual circumstances, but soft, like newly made morter, but it dried and hardened before he could get it all out, and it was then nearly as difficult to scrape as the ordinary hard scale. On one voyage, when he was present himself, he gave the boiler as much feed as the pump would do, and he observed then that the water in the gauge glass was muddy. He continued the experiment for six months, but with lesser quantities of feed, and blew off till the tubes of the regenerator gave way, and then he discontinued. He saw then M. Coutu's paper, and the table contained in the same, which shows how necessary it is to have the deposit of precipitate matter could be got rid of. This table exactly with the experience of some others. Some steamers in the American navy work with about or nearly 30 lb. pressure and salt water, but it is believed not with our ordinary tubular boilers, but with long cylindrical boilers; and it must be remembered that there was no current. There was not much more deposit than when working with 25 lb. He believed that there was a greater tendency for the lime to separate and deposit than it did not necessarily settle down on the heating surface of the boiler.

The Mechanics' Magazine, in an article on Incurration in Marine Boilers, February 24th, 1860, mentions Mr. James R. Napier's paper, and gives account of the working for want of being known. For 20 lb. pressure, and the same amount of solution as the limit of saturation in boilers working at a pressure not exceeding 20 lb., and finds that, with this assumption, half the water must be discharged to keep the boiler clean, and this is affirmed by the notice of the British and American Marine Company and others. Mr. Thomas Rowan found that when he had evaporated

$\gamma$ of the water a trace of sulphate of lime deposited
$\gamma$ $\gamma$ $\gamma$ sulphate of lime deposited in large quantities
$\gamma$ $\gamma$ $\gamma$ $\gamma$ decided

and salt began to form. It is probable, therefore, that half or more of the water would have to be blown off in order to prevent formation of crust. This means that the density of the water should be kept at $\gamma$, for as sea water contains $\gamma$ in its pure state, it is evident that half the water must be blown off to keep two double its natural density. It may be here remarked that a density of $\gamma$ is very generally kept in marine boilers, using about 20 lb. pressure of steam, and this is constantly and carefully attended to, no considerable or delerious losses of scale accumulate, at least in places where the circulation is good.

We come now to a brief survey of the various means proposed or adopted for preventing incrustation. They consist in

1. Use of condensers.

2. By heating the feed-water to such a temperature before entering the boiler, so as to oblige the sulphate of lime and other salts to accumulate in the heater only.

3. By introducing various substances into the feed-water before entering the boiler, the feed-water at the same time being subjected to heat so as to throw down the salts without allowing the same to enter the boiler.

4. By introducing various substances into the boiler so as to neutralise the effect of the salts, and

5. By blowing off in the usual or various other ways.

1. Surface condensers: This seems at once to do away with the nuisance; the economy anticipated has not, however, been quite realised in practice, because the water from the condenser is thrown into the sea with the distilled water and along with the distilled water from the condenser, and the duration of the boiler has been found in many cases to be even shorter than with salt water, on the reasons for which it is not thought necessary to enter into here.

2. Heating the feed-water before entering the boiler to such a degree that the salts are supposed to be thrown down into the heater instead of the boiler. This looks very feasible, but after all it amounts to the same thing as blowing off; let the boiler be blown off to a greater extent and with less water. This has been tried and also by the introduction of salt and incrustation, and the engineer in charge has his hands as full as ever.

To be admissible on board ship it must be compact, and at the same time accessible for thorough scaling; two conditions not very easily reconciled. The most practical shape is that of a casking with a number of diabes or shelves piled on the top of each other, which can be taken out and replaced by clean ones in a short space of time. This plan has been patented by Mr. Spencer, No. 896, and in 1864, No. 88, by M. E. Martin, a French civil engineer. It is possible that this idea, by no
IMPROVEMENTS IN PARIS.

There is no diminution in the work of demolition and reconstruction which has for several years proceeded with such unprecedented rapidity, and which has brought into existence, or brought to obli- vion nearly all the old landmarks of the city of Paris. The alterations which have been made in the neighbourhood of the Champs de Mars, with a view to the coming Great Exhibition, are proceeding with more than ordinary vigour, and are giving life to the Place de Trocadero for the new Place of the King of Rome, so named from the fact that it was on this spot that Napoleon proposed to erect a palace for his son, the young "King of Rome," as being carried on by night as well as by day. Thousands of cubic yards of earth are being removed from the Beaux to the Champs de Mars every day. It is at night that the sappers fire the mines that are gradually reducing the heights of the Trocadero to masses of rubbish. The earthworks are completed in parts, and the ground is being levelled for the great Place de la Concorde, in front of the Palais de la Cité. This esplanade will be upwards of 1,800 feet in length by about 800 in width, and will be eight wide boulevards or avenues, in addition to the bridge of Jena, leading from it to various parts of Paris and Passy.

An interesting discovery was made the other day in the old island of the Cité, in the demolitions now going forward on the site of the new building for the hospital of the Hôtel Dieu. An enormous oak beam, more than fifty inches square, was found in one of the oldest houses; it was cut up, or decayed, and on one of its faces was found the following inscription, in rude characters, but perfectly legible: "This beam was placed here in the year 1450, and I was 800 years old when I was taken out of the forest of Royray." If this description is authentic, and the age of the tree was not overestimated, the tree from which this gigantic piece of oak was taken must have been cut down centuries before, but it still contains the beech and oak, Charolais, and the wood must now be more than 1,000 years old. One of the most remarkable instances of reconstruction now under hand is that of the corner of the Palace of the Tuileries nearest the river, called the Pavilion of Flora, and the long gallery which connects it with the Louvre. The pavilion, finished as regards the main work, is now in the hands of the sculptors and decorators, and begins to present a view of the great and the resplendent. The upper part of the pavilion has two very important decorations; on one hand, an ornamental gallery, with a beautiful gallery of which it is a continuation. It is, moreover, the most important part of the decorated work which has been undertaken in Paris for many years; the whole of the upper portions of the building are covered with sculpture and ornament, and the lower front is Doric, with pilasters ornamented with vine and ivy scrolls. The lock is placed in the spaces between the pillars' heads, crossbar of the Legion of Honour, and base. The pediments are alternately curved and pointed, and the frontons are decorated with the arms of various works: agriculture, by M. Carrier-Belleuse; Navigation, by Madame Boitié; Mathematics, by M. Grévin, and the Louvre, by M. Choiseul-Gouffier, Amphitrite, by M. Cabot; Concord, by M. Walker; and Sculpture, by M. Perray. The roof is pierced by two rows of square and rectangular dormer windows and otherwise ornamented. The inner side of the wing is of the same date, and the model of the central portion of the palace, by Phillipe Delabrière. The ornamentation of this portion is exceedingly rich; near each window is a seated figure, corresponding with the subject of the decoration, executed in relief, and surrounded by laurels, and above these are groups of animals by the sculptors Delabrière, Cani and Premont—two lynxes chained, and a Minerva; two dogs and a globe sprinkled with bees, and crowned with an imperial diadem; two hounds and a woman's head, with branches of oak and laurel; two otter hounds attached to a stag's head; two panthers chained round the paws of the lions; and lastly, the head of the huntress, by M. Merley, and beneath it are two figures of hunters, with implements of the chase. The second fronton is devoted to glory, and is from the chisel of M. Gessner; beneath it is a man with a trident, and a horse, which is a horse.

The subject of the third fronton is the rape of Europe, by M. Demeysne, with figures of a German warrior and a Roman soldier beneath. The fourth fronton is decorated with a group entitled History, by M. Franceschi, with figures of a first floor in a sculptor below. The fifth represents a Dryad, by M. Delaplanche, and beneath are Neptune and a youth, representing a river. On the sixth fronton will be a figure of Venus, by M. Vitani, with Tritons blowing trumpets. The seventh fronton will be the work of M. Gresse, and the last one is by Samson. On the eighth M. Perrault is to execute a Victory, with warriors below. The ninth and last fronton, which projects beyond the rest, are to be Cupid, by M. Soltonz, with figures of a woodman and an artist. On the entering angle, between the eighth and ninth frontons, will be two figures, Apollo holding a lyre and a laurel crown, and Paris with orock and apple of discord. The whole of the pediments are by a balustrade, on which are vases decorated with masses of fauna, and crowned with flames. The roof on this side has a double range of dormer windows, and behind them is a row of statues, the whole being executed in that rich lead repousse work, which has lately been revived with such admirable effect. In this mechanical age of much encouragement cannot be given to works of this class, which form the link between the Park of the Tuileries, the Grand Louvre, the Tuileries, the Hotel De Ville, and other buildings, present much deserving study in this kind of work. Before the summer is over the whole of the newly-constructed portion of the two pavilions will be completed, at least as regards the interior, and the grand river front will then present a consistent whole, the beautiful work of the sixteenth century being no longer brought into comparison with the heavy inartistic building of the eighteenth century.

LOCKS AND KEYS.

At a recent meeting of the Institution of Mechanical Engineers, a description of a new construction of lock and key was communicated by Mr. J. B. Fenby, of Birmingham. The writer pointed out that in all previous locks there had been two important defects in principle, which are fatal to their security—the first being that, although access to the works of the lock is greatly impeded by many ingenious contrivances, they still admit of the works being got at through the keyhole, and thus enable the thieves to obtain the utmost advantage when the lock is not fully defended. The second defect is the possibility afforded for repeating the trial of a false key, and thus perfecting it by successive alterations after trial. In the new lock described in the paper, which is the invention of the writer, the lock is divided into two parts, the bit or wards taking the shape of the initials of the name of the person from whom a copy of the key is obtained. The second is in the cylinder then turned round by the stem of the key actuating the centre keyhole; the bit, while being carried round is also pushed outwards along the radial slot by means of a cam, and is thus made to protrude from the circumference of the cylinder sufficiently to act upon the levers of the lock, and thereby set the bolt at liberty to be withdrawn. The bit is then pushed out of the radial slot, and drops into a receptacle inside the door: and the further revolution of the cylinder withdraws the bolt, and unlocks the door. The consequence of this mode of construction is that, as soon as the bit has been inserted in the lock and the cylinder is turned, the radial slot in the cylinder is carried away from the keyhole, which is completely closed by the solid cylinder, whereby all access to the interior of the lock through this opening is effectually prevented, nor can anything be used to pass through the opening, excepting that bit by the key which the lock is opened. The centre keyholes, into which the stem of the key is inserted for turning the cylinder, is simply a blind socket with parallel sides, and without any communication with the radial slot. When the lock is to be opened, the cylinder by fraudulent means lies, therefore, in the use of a counterfeit bit introduced into the lock in place of the true bit; but this counterfeit is absolutely lost to the operator and retained inside the safe at the very moment the bolt is withdrawn from the opening. The bent, but from the attempt itself no clue whatever is obtained as to the nature of the defect in the counterfeit. In consequence of the same not being accessible for feeling through the keyholes, and therefore not requiring the genuine bit is fixed to the key, and the key is turned upon the bit, each lever can be shaped to its own proper curve, and the play in the action of the levers is thus reduced to a minimum; hence a much smaller amount of error in the counterfeit than is admissible in the case of previous locks will prevent its opening the lock. The importance of these advantages in the principle of the new lock is illustrated by the
celebrated bullion robbery on the South-Eastern Railway some years ago, which called attention from the public to the manner in which it was accomplished and the large value of the property stolen; but even in this case success was not attained until as many as seven trials had been made with the same false key, the latter being altered after each trial according to the indications obtained from the evidence until, when it was at last sufficiently perfected to be capable of opening the lock of the bullion safe. In that instance also the successive trials were made without leaving any indication behind that the lock had been fraudulently attempted, although the trial key was left behind in the lock, which was afterwards unlocked by the thief. In the present case the lock was subjected to the pressure of a machine specially contrived for that purpose, with a perforating arrangement, having an extent of permeation admitting of each lock differing from every other lock made. For locking the lock, the stem only of the key is required, as the bolt is shot simply by turning the cylinder; and as the keyhole for the stem is formed with a notch cut out on one side only, while the cylinder is not permitted to make a complete revolution, the key stem cannot be inserted. For unlocking the lock, the lock must remain unlocked. This lock has an important advantage in simplicity as well as solidity of construction, as there are no more than sixteen separate pieces altogether in the complete lock; moreover, as both keyholes are simply blind holes with parallel sides, having no communication with the interior of the lock, they do not admit of injury to the lock by the explosion of gunpowder. Specimens were exhibited of the new lock, the section of which was shown both with the true key and with counterfeit keys; and it was shown how the counterfeit failed to open the lock. Withstanding that, by means of the perfusing cutting machine, it had made a much nearer approach to a perfect copy than was practicable in the best hardware from a wax impression. The key-cutting machine, which took the key, was also exhibited, having been lent for the purpose by Messrs. Whitefield, Birmingham, the makers of the locks.

INDIAN RAILWAYS IN 1865.

Sufficient time has now elapsed since the Government first gave its aid to the establishment of railways throughout our Indian Empire, to furnish data as to the expense of the lines when completed, and the probable profit and loss of the undertakings. From a multitude of sources, from the Government report of Mr. J. Landers, from figures published in India, from the writings of Mr. W. P. Andrew, chairman of the Seine Railway Company, from the survey of the Euphrates Valley, by Major-General Chesney, and from other authorities, a mass of statistical information is now before the present position of railways in India, and the probability of the future union of that system with the lines of Europe.

At Midsummer, 1865, the number of miles of railway opened for traffic in India was 3,186, and the length remaining to be finished, 1,793, making a total of 4,919 miles, consequently about two-thirds of the present position of railways in India. The total of the ten Indian railways and their branches, the following number of miles are open for traffic:—East Indian, 1,126; Great Indian Peninsula, 564; Madras, 517; Bombay, Baroda, and Central India, 806; Seinde, 114; Punjab, 258; Punjab, Delhi, none; Eastern Bengal, 111; Great Southern, 79; Calcutta and South-Eastern, 29; total, 3,186.

The miles of the sanctioned lines yet to be finished and opened are:—East Indian, 370; Great Indian Peninsula, 670; Madras, 281; Bombay, Baroda, and Central India, 6; Seinde, none; Punjab, none; Punjab, Delhi, 320; Eastern Bengal, none; Great Southern, 82; Calcutta and South-Eastern, none; total, 1,790.

Here it will be seen that Bombay and Calcutta are not yet united, 670 miles of the Great Indian Peninsula Railway having to be finished before the English mails find a quicker route than going all round India. This link is not likely to be completed before the next 20 years. Between Madras and Bombay there is another unknown district through which it is hoped a railway will run to the Euphrates Valley and Turkey in Asia. With very little exception, the whole of the lines in India, finished and unfinished, are single, and the trains travel at a very slow rate of speed. On the East Indian there are 67 miles double, and on the Great Indian Peninsula 57, making a total of 124 miles. Besides this, the doubling of 42 miles more on the latter railway has recently been sanctioned; all the rest, finished and unfinished, are single lines. In 1863, the number of miles open for traffic was 2,516, and on these open lines 194 accidents occurred in that year, 118 of them being fatal. This is a very high rate, the number of passengers in the twelve months being 987,800, but only eighteen of the number were killed, the accidents being caused by the causes beyond their control. Of these eighteen, eight were passengers, and ten servants of the railway. Three of the eight were killed by a train being thrown off the rails by a stray buffalo, two lost their lives by a train getting off the line through negligence, and the others were purely accidental. In Mr. Manners's report one was described as caused by "the bite of a tiger," which, without explanation, appears a strange railway accident; and another fatal case was that of a passenger who jumped out of a train while it was on fire.

The following is a summary of the rolling stock employed on all the Indian railways, up to the end of the year 1864.

<table>
<thead>
<tr>
<th>Railway</th>
<th>Locomotives</th>
<th>Carriages</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Indian</td>
<td>371</td>
<td>518</td>
</tr>
<tr>
<td>Great Indian Peninsula</td>
<td>118</td>
<td>570</td>
</tr>
<tr>
<td>Madras</td>
<td>70</td>
<td>165</td>
</tr>
<tr>
<td>Bombay, Baroda, and Central India</td>
<td>65</td>
<td>200</td>
</tr>
<tr>
<td>Seinde</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>Punjab</td>
<td>11</td>
<td>88</td>
</tr>
<tr>
<td>Eastern Bengal</td>
<td>60</td>
<td>320</td>
</tr>
<tr>
<td>Great Southern</td>
<td>11</td>
<td>88</td>
</tr>
<tr>
<td>Calcutta and South Eastern</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>462</strong></td>
<td><strong>1,460</strong></td>
</tr>
</tbody>
</table>

The capital expended for rolling stock since the first Indian line was commenced, up to the 1st of May, 1865, was £54,942,029, the expenditure during the past year only being £2,826,044, of which about £2,418,345 was spent in India, and £1,387,699 in England. To meet this expenditure, 36,638 shareholders subscribed up to the 31st of December, 1864, £58,000,000. Of these shareholders 33,303 were registered in England, and 777 in India, 365 only of the whole being natives. Hence it is evident that residents in England consider Indian railways a good and safe investment for capital. The number of debenture-holders at the end of 1864 was 6,453. The rate at which capital has been expended upon Indian railways during the past fifteen years is shown by the following figures:—In 1850, £176,150; 1851, £231,523; 1852, £407,590; 1853, £207,449; 1854, £231,523; 1855, £367,636; 1856, £3,417,268; 1857, £349,125; 1858, £2,72,672; 1859, £2,652,770; 1860, £6,555,271; 1861, £58,320,862; 1862, £4,771,776; and 1863, 3,801,044. The total loss to Government during the year 1864, after allowing for the profit gained by the lines at work, was £130,000. ...
The excessive ratio of working expenses of the Great Indian Peninsula Railway in the above table is owing principally to the compensation paid during 1864 for cotton destroyed by fire or detained at the Thull Ghaut. There are such discrepancies, however, in the other figures, that special investigation as to this matter of working expenses seems necessary. The East Indian Railway, especially, has an expensive establishment, much more than residents deem necessary for the efficient working of the line, which has a series of very magnificent stations. Officially in India should be highly paid, and we are not advocates for shabby stations; still this, and perhaps other companies, seem to have gone beyond the fair medium.

The fares on the Indian railways vary as follows:—First class, from 1d. per mile on the Suburban Railway to 1d. on the Bombay and Baroda. Second class, from 1d. on the Madras Railway to 1d. on the Great Indian Peninsula, and several others. Third class, from 1d. to 3d. half the charges being the one amount and half the other. There is a fourth class at 6d. per mile on the Eastern Bengal, and Calcutta and South-Eastern Railways.

The following shows the amount of guaranteed interest paid by Government during 1864, as well as the total amount paid since the first railway in India was commenced:

<table>
<thead>
<tr>
<th>Railways</th>
<th>Interest paid up to December 31, 1864</th>
<th>Interest paid during 1864</th>
<th>Total to December 31, 1864</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Indian</td>
<td>£3,590 10s. 1d.</td>
<td>£3,577 46s. 19 7</td>
<td>£3,577 46s. 19 7</td>
</tr>
<tr>
<td>Great Indian Peninsula</td>
<td>5,396 27s. 10 6</td>
<td>626 46s. 15</td>
<td>5,072 2 5</td>
</tr>
<tr>
<td>Madras</td>
<td>1,400 197 6</td>
<td>342 26s. 14 9</td>
<td>1,362 46s. 7 10</td>
</tr>
<tr>
<td>Bombay and Baroda</td>
<td>239 48s. 5</td>
<td>82 60s. 9 7</td>
<td>321 80s. 12</td>
</tr>
<tr>
<td>Bengal</td>
<td>1,288 11 11</td>
<td>123 27s. 15 1</td>
<td>1,411 46s. 13</td>
</tr>
<tr>
<td>Delhi</td>
<td>1,978 11 1</td>
<td>257 17s. 1</td>
<td>2,235 34s. 1</td>
</tr>
<tr>
<td>India Steam Flotilla</td>
<td>374 80s. 8</td>
<td>98 80s. 8 10</td>
<td>472 80s. 13</td>
</tr>
<tr>
<td>Bombay, Baroda &amp; Central India</td>
<td>483 143 11</td>
<td>232 71s. 19 9</td>
<td>715 26s. 2 9</td>
</tr>
<tr>
<td>Eastern Bengal</td>
<td>307 70s. 7</td>
<td>700 00s. 0</td>
<td>1,007 70s. 7</td>
</tr>
<tr>
<td>Calcutta and South Eastern</td>
<td>55 90s. 5</td>
<td>19 80s. 11 13</td>
<td>74 70s. 13</td>
</tr>
<tr>
<td>Great Southern</td>
<td>61 94d. 7</td>
<td>26 60s. 9 7</td>
<td>87 54d. 7 7</td>
</tr>
<tr>
<td>Total</td>
<td>13,604 736 3 9</td>
<td>3,657 743 14 7</td>
<td>13,101 538 17 0</td>
</tr>
</tbody>
</table>

Of the above total paid by the Government during 1864, £5,393 9s. 6d. was paid in England, and £34,361 15s. 4d. in India. Of the total amount paid from the first up to the end of 1864 by the Government, in the shape of guaranteed interest, £3,300,000 has been paid back by the earnings of the railway companies. When the traffic on the railways yields a profit of more than 5 per cent., the Government payment of interest, of course, will cease, and half the surplus over 5 per cent. will go to the railway companies, the other half going to the Government. Of the shareholders receiving the guaranteed interest, one half hold less than £1,000 stock, and, as already stated, nearly all reside in England. These shareholders appear to have as much confidence in the Indian railways as in the funds, and there is usually a lack of applicants for more shares when any are issued.

The above, in a compact form, gives all the principal points of interest respecting the railways of our Indian empire, up to and in some instances later than December 31st, 1864.

Of the railway servants employed, only about one in twenty is a native, and the natives only receive one-third or one-fourth the salary of Europeans, the latter being required to occupy the position of responsibility and places where skill and nerve is wanted. The natives make very good clerks and stationmasters, but are useless as engine-drivers and pointmen.

In regards to the health of the European officials during the past year, twenty-two died and seventeen retired through ill-health. Of the deaths, eleven took place on the East Indian line, five on the Great Indian Peninsula, two on the Madras, one on the Bombay and Baroda, two on the Punjab, and one on the Calcutta and South-Eastern. The average number for the four previous years was thirty-five per annum, so the mortality last year has been considerably increased. The mortality among those who go out to India averages rather less than one per annum, but many are prevented from leaving England by the examining physician refusing to pass them. Mr. William Brinton, M.D., F.R.S., is the gentleman who examines most of the candidates for the Indian railway service, and he says that he has been compelled to reject one or two every year during the past year. This proportion must be regarded as a low one, especially on consideration that a large number of the candidates had previously undergone a medical examination before appointment on the English railways. Many so employed in England show symptoms of premature decay to such an extent that no good London insurance office would accept them as first-class lives. Workers in metal, and those continually engaged in piece-work, exhibit these lessons or tendencies most, and it unites them to resist the change of climate or to withstand hard work beneath the burning sun of India. Dr. Brinton states in proof of this assertion that the average age of the persons examined is thirty, in five cases more than forty, and in three cases between thirty-five and thirty-eight. Railway officials in India are liable to a heavier rate of mortality than recruits despatched there for military purposes, unless the latter be on active service. The surveying and construction of railroads expose the engineers and others to trying ordeal, and to the heat of the monsoon while the mail is passing, and to the foot of some of the Indian mountain ranges, more especially the Himalayas, a belt of marshy forest ground is often found, where even the native cannot live; yet, wherever the railway goes, there must the officials go also. Dr. Brinton states that the capabilities of the overland journey, and the very sudden change of climate below the route of the English constitute European constitutions than the old route round the Cape of Good Hope. He recommends the latter whenever it is possible to choose it. Those officials passed by him are, as a body, remarkable for their vigour and health before leaving England.

The difficulties overcome by the engineers within the last year or two, to bring about the grand results that have occupied our attention, have been noticed from time to time in this journal. The Bhore and Thull Ghaut inclines, on the Great Indian Peninsula Railway, have broken through the great mountain range into the cotton districts of Central India. The Bhore Ghaut incline is more than 1,400 feet in a little over a mile, in the midst of the grandest mountain scenery, and the Thull Ghaut has an incline of 1,000 feet in ten miles, the steepest gradient being 1 in 37 for 4 miles 30 chains, and the sharpest curve 17 chains radius for a length of 35 chains. There are thirteen tunnels of an aggregate length of 2,682 yards, and viaducts to the water here in hosts for some months, the annual flood, and 300 feet high. The cost of this incline was £50,000 per mile. The cyclone, which did so much damage at Calcutta about a year ago, spent some of its fury on the railway terminus there, the East Indian sustaining damage to the amount of £6,915, the Eastern Bengal, £32,889, and the Calcutta and South-Eastern £2,730; total £32,845, which were the effects of the great hurricane, which is supposed to have originated at the Andaman Islands, a nest of storms, and a place where two troop-ships, according to Dr. Mount, were once blown clean out of the sea into the jungle. In the storm now under notice, not one single man was injured, but the engine and part of a train on the Eastern Bengal Railway. On the western side of India the monsoon, in the middle of the year, is stated by Mr. Jualdan Danyers to have caused much damage by its floods. On the 27th of June the embankments of a culvert were washed away on the Great Indian Peninsula Railway, and on the following day 12 spans of Soft. iron girders was destroyed. A night train passing, the rails ran into the gap, and fourteen native passengers were unfortunately killed on the spot. Six spans of the great bridge over the Nerubda river were swept away by the floods, and the traffic of the Bombay and Baroda Railway had all to be carried across the Nerubda by means of a hand ferry.
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

The quantity of materials sent out in 1854 for the construction, maintenance, and working of railways in India, amounted to 102,318 tons, in 238 ships. The value of the goods shipped was £1,019,164, and the amount paid for freight and insurance, £164,638.

The rate for first-class passengers on the East India Railway is 9d. per mile for second-class 1½d., and for third-class 3d. The first-class fare from Calcutta to Delhi is 95 rupees, the second 48 rupees, and the third less than 16 rupees. If we contrast the time—three months—that it took not fifteen years ago to make the same journey, and compare the £9 10s. with the enormous sum paid formerly, it may be acknowledged that railways are working wonders in India. The Calcutta Engineer.

HIGH ART IN LOW COUNTRIES*.

By the Dean of Ely.

There is one preliminary question which stares us in the face. What do we mean by art? And though this is a simple question, I am not sure that it is easier to answer on that account: in fact, it is not unfrequently just the simple preliminary questions which are least likely to meet with satisfactory answers. Ask many persons who use the terms to define what they mean by a Whig or a Tory, or a right-angled triangle, or a respectable dog, or a general, and generally you will find that God alone can tell. It is difficult to get a clear answer; and you may be reminded of the wisdom of a certain leader of the House of Commons, who, having endeavoured in vain to obtain a definition of the duties of an Archdeacon, and being compelled to make a speech which involved the knowledge of those duties, began by saying that the duties were known to be such that he could not take up the time of the House in explaining what they were. What then, I say, do we mean by art?

In the first place, with regard to the word: it is, of course, the same as the Latin word Ars, artes, and as the French Art. The form is not very interesting; but there is, I think, some interest connected with both words if we trace it a little further. The dictionaries tell us that the Latin word Ars is the same word as the Greek Αρτος; and this Greek word, which signifies any kind of ability or skill, but originally denoted more especially warlike ability or skill, courage, valour, is probably connected with Ares, the Greek god of war, the Mars of Latin mythology—a connection which I notice, because certainly art, as we understand the word now, art as the word is used in such a phrase as "The Wisbech Industrial and Art Exhibition," would have chosen any god or goddess in Olympus as its patron in preference to Ares or Mars, the fierce god of war; and if so, the same which originally described the god of Achilles or an Ajax can now be used with most emphatic propriety to describe the power of those who beautify the houses of God and adorn our homes, then we may perhaps see in the change of meaning something of that change which is described by the prophet when he speaks of men "beating their swords into ploughshares and their spears into pruning-hooks," and "learning war no more." Again, the dictionaries tell us that artes is probably connected with ardo, a male, the Latin virtus is connected with vir, a man; virtus signifying originally valour, courage, those qualities which were considered to be the chief glory of men; but virtue is now no longer any special property of men. I should think that quite a sufficient claim for women that they should be put on an equal footing with their fair sisters; more than their half of the virtue which exists in the world I am certain they have not got. And so, also, if art originally implied anything of masculine skill, many valour, warlike craft unsuitable for women, we may congratulate ourselves that it is as long as it is, in the sense in which we are dealing with it to-day, belongs to men and women alike.

Let us, then, leave the word and come to the thing. Art may be regarded in the first instance as meaning skill in general; but we treat it as meaning skill of a particular kind. And I think that we may properly define what we mean by saying that art is that which is done not only with the useful but with the useful and the beautiful. Let us consider this definition.

Many things are useful without being beautiful. There is no beauty worth speaking of in a gasworks-chimney, or in a newspaper, or in a railway-carriage; yet all these things, and thousands more which might be mentioned, are singularly useful. It is not every useful article, perhaps, which admits of a covering of beauty; in some things the intensity of usefulness seems to make beauty unnecessary, or perhaps to make the attempt to add to it ridiculous; their usefulness, in fact, is beauty, and with that they must be contented. Nevertheless, it is surprising how very few (comparatively speaking) are the cases in which superadded beauty is impossible, and, therefore, art unnecessary. In fact, the instinct of art would seem to be almost universal with the instinct of supplying the prime necessities of human life. Amongst the earliest remains of human handwork which recent discoveries have brought to light are rude carvings upon pieces of bone, which no doubt were regarded by the connoisseurs of those days as ornaments. Man, compelled by his necessities first to make tools, but they soon began to ornament those tools; and I suppose there is not a savage nation on the face of the earth in which utility is everything and art nothing. On the other hand, art appears to belong to man's simplest nature; and it is only in a very advanced state of society that men think it a mark of superior sense and judgment to glorify utility at the expense of beauty.

Nor is it to be wondered at that man's nature should be thus constituted, seeing that God made man, and that the principle of clothing the useful with the beautiful, which I have spoken of as the foundation of art, is just the principle upon which the human heart is most naturally constructed. Look at the human figure, the human face, the human hand, the leg, the foot. Every portion is useful; but not only so—every part is beautiful; and the beauty and the utility are married together. We may speak of the eye as an optical instrument; but when we speak of the bright eyes of a woman, or the beauty of the face, we imagine other things than instruments. And the mouth is a very utilitarian organ, and has very commonplace work to do; but there is hardly anything more beautiful and more expressive than the human mouth, and we are not thinking of mere utility when we speak of ruby lips. So of other parts of the face and of the body. Organs which, with other animals, are like the heart, are packed away in closets; and the human frame as presented to the eye—especially if not spoilt by barbarous costume—is a perfect specimen of the useful clothed with the beautiful: in other words, it is a perfect type of that which, in human works, we describe as art.

The useful and the beautiful, then, are combined in a work of art; and let me observe that the degree in which each of these two constituents will predominate varies very much in different cases. In some the use is almost everything, and the beauty superadded is trifling; as, for instance, when two kinds of bricks are laid together, or two kinds of stone or of marble, to build the uniformity of the walls; in others the utility has almost vanished to make room for mere beauty, as in the case of pictures. But, as a general rule, art does not seek mere beauty, but follows the example of nature, in which use and beauty go together, and utility is often an absolute condition of beauty; yet even in nature we sometimes find the beautiful almost as music in the case of a picture; thus we have the gorgeous colours of the morning or evening sky, and on a smaller scale we have the butterfly and the humming-bird.

Hitherto I have been speaking of art as though it addressed itself entirely to the eye; and, in fact, the kind of art to which this Exhibition chiefly directs our attention is that which belongs to the sense of sight. But it ought to be observed, if only for the sake of justice, that the eye has not a monopoly of the pleasures of art. Art acts upon the mind, like almost all other things, through the senses; but there are only two of the senses which appear to be capable of being associated with art properly so-called. These are taste, for example, might claim as its peculiar field the art of cookery; but we must not in an application of the term admit cookery to the dignity of art; and the sense of smell might claim that art which is hereditary in the family of Jean Marie Farina, of Cologne—but neither must the composition of perfumes be admitted into the dignity of art. The imagination, though the sense of taste, for example, might claim its right to a part of the domain, is not, I think, a sense in which we are dealing with it to-day, belongs to men and women alike.

An Address delivered at the opening of the Wisbech Industrial and Fine Art Exhibition.

* High Art in Low Countries.
choral worship of a beautiful cathedral; indeed, one may say that the entente cordiale between these two senses is complete, so that sometimes they interchange names with each other; thus, when I see a letter from a friend, I say that I am glad to hear from him, and when he writes to me, by word of mouth, some difficulty, I say, "Ah, now I know what you mean.

It is no disconcert, therefore, to those branches of art which have the ear for their орган, that we do not consider them today.

We are dealing with art chiefly or almost exclusively as it belongs to the eye, and in so dealing with it I think we may adduce definitively in this instance of this art - the clothing of the useful with the beautiful. The question, therefore, which it would seem to me should be prominent in the minds of those artists whose efforts we chiefly desire to stimulate by Industrial and Art Exhibition is this - How shall I make my work beautiful? How should I produce that which is in good taste? And this question, like many others, is very briefly asked, but cannot be very briefly answered. Something, however, may be said which may be of use, and, with your permission, I will devote a few sentences to the subject.

I would observe that there are three great elements of beauty which ought to claim the attention of all art-workmen, and which comprise the whole of the beauty of the stock-in-trade. And the three great elements to which I refer are - Form, Proportion, and Colour.

The importance of form is illustrated by the fact that with the Latinas forma was actually equivalent to beauty; and so thoroughly does form imply beauty, that, if the form be good, it is almost indestructible, and it is often the case that position is more trying than that occupied by St. Paul's Cathedral in the midst of London smokes. There it stands from year to year with the accumulations of the atmospheric filth of perhaps the filthiest atmosphere in the world; and if the dome depended upon the colour of its material for its beauty, alas! for the dome! But if the fabric be well designed, catches your eye, lighted up by such daylight as the city of London enjoys, you cannot help saying that it is one of the finest buildings in the world.

The education of the eye to the delicate perception of form, and the quickness to the production of form, are, I conceive, amongst the prime requisites of art-education; and it is a kind of education which is the more important because the tendencies of modern times are in some respects unfavourable: there is such a tendency to manufacture things on a large scale, to use the rule and compass rather than the eye, to meet the demand by the product of the press rather than by the conception, that there is danger of men being frightened away from sound principles of honest art by the dread of being starved in the process of carrying out the principles. Let me illustrate the importance of form by reference to something which I remember hearing from Professor Willis. Professor Willis invented an ingenuity which he saved his years of practice, and which is in the use of obtaining correct drawings of the mouldings of Gothic architecture.

It is not very easy to do this, anyone will perceive who remembers how deeply under-cut and hollowed out many of these mouldings are; however, Professor Willis invented the cymograph, and he did so because he had long been struck by the contrast of effect between ancient and modern work which professed to be merely an imitation of the old. Now, when the two came to be fairly laid side by side upon paper, by help of the cymograph, what was the difference between them? Just this, that in the case of the ancient work the lines of the mouldings were drawn by the artist with a free hand; whereas, in the modern, every curve was with a compass. The ancient architect, in fact, went by the rule of brains, and the modern by the rule of thumb; and I well remember the perplexity caused by this distinction to a very clever and competent man, who for a time superintended the recent restoration of St. John's, Lancaster. Mr. Scott had asked him to make the working drawings of the old art works; the design were by the good man attempted to do so according to modern rules of art; but to his dismay he could find no contours from which to strike his circles, and every modern rule of stonework was ruthlessly set at defiance. If you had asked the great architect of the old with what do you mix your stonework? he might have answered, like the artist in Dr. John Brown's Essay, who being asked, "With what do you mix your colours?" replied, "Wi' brains, sir."

So much for form; proportion is equally important. Indeed, it may be said that proportion is an element of form, that form depends very much upon proportion. Still, proportion deserves separate consideration, and I should be very glad to give it such consideration as my poor ability might enable me, if it were not for the necessity of studying proportion also in my address, and hastening to conclude this portion of it, and proceeding to that which is more particularly implied by its title.

For the same reason I must pass, with a rapidity which much grieves me, over the subject of colour. I must remark, however, that there is in every true artist a great deal of it, and great encouragement to Englishmen to endeavour to do it. There is a great deal to be done, because, until lately, colour was in many departments of art almost forgotten, especially in architecture. We seemed some years ago to regard as an axiom that we should have no colour except those of wood and of stone. Now we are beginning to wake to our mistake; and the danger is lest, in the zeal of our returning consciousness, we should rush with brush in hand and commit some tremendous blunders. It is for fear of committing such a blunder that the lantern of Ely Cathedral is now left in its unfinished condition. It was thought better to look at the woodwork in its old, crude, lighted, not simply and considerably at the work, rather than paint the whole in a hurry, and repent of the result at leisure. But there is, as I have said, great encouragement to Englishmen to work at the colour department of art. Englishmen have not, I think, as a nation, good eyes for form and proportion. Certainly we do not in general draw so accurately as the French, nor are we able to hold a high position as colourists; and in any international exhibition of pictures, perhaps nothing will strike you more than the excellence of the colouring of works of the English school. Let me dismiss this part of the subject by saying that colour seems to me to be a very special and peculiar way a gift of God. Form and proportion are not given; God gives us the power of appreciating the beauty which arises from them, and sets us examples of such beauty in His works; but the beauty of form and proportion is, after all, connected with geometrical necessity, and, therefore, in part at least, divine benediction. But colour and therefore all the beauty and pleasure arising from it, is the result of a distinct creative act, which (as far as we can perceive) need not have been performed.

"God said, 'let there be light,' and there was light;" but when God created light, He created colour too. The beam of light is not simply an insensible emanation, capable of discharging the useful office of conveying messages to the eye; but the white wave was made capable of splashing into numberless colours; and the great discovery which Newton made, not much more than a century ago, was in reality the discovery of a primeval act of God's providence, of which men had perceived, for ages not simply and considerably at the work, but before, through the environment of their existence, though they were in ignorance of the method of God's operation.

I have now spent as much time as I can afford upon the general question of art, and I pass on to the more direct discussion of the subject which I have chosen particularly for this address, and which I have shadowed forth in the epigrammatic title "Art and Art in Low Countries"

I do not know whether the notion is generally prevalent, but I confess that to me it seems very natural, that districts such as this in which Wisbech is situated should be unfavourable to the flourishing of art and the birth and growth of art genius. Far be it from me to say anything disrespectful concerning the Isle of Ely, but its best friends will not deny that it is deficient in picturesque features, and that there is not much in it to stir the imagination, or drive men to write poetry in celebration of its natural beauties. The wild lands of mountains, waterfalls, woods, and rivers, seems to be, as Sir Walter Scott phrases it, the "true nurse of the poet's child," in the midst of ditches and fens. It is true that here and there may be seen traces of ancient art and antiquity; and hence I think there is a tendency to imagine that the child of art is likely to fare as badly in our fen country or in Marshland as the child of poetry. But in truth any such imagination would be unfounded, and would be contrary to experience. That this may be proved I shall now to the broader more abstract the present article,

in the first place, it seems to me that the very absence of natural beauty in a flat country is likely to force the minds of the inhabitants in the direction of art. The possession of every-

THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL

[July 1, 1866]
thing upon which the eye can delight to rest all ready-made (as it were) by the hand of nature, may have the effect of checking the appetite for art, whereas the fame of natural beauty may compel a search for artificial food. Certain it is that the earliest works of art are to be found in the prosaic valley of the Nile, and in the desolate wastes of the desert. But there must feel that the existence of beautiful churches, such as we find throughout Lincolnshire and the Marshland district of Norfolk, is a boon which in a more interesting country we should not appreciate nearly so highly.

But, in the second place, I think it should be borne in mind that a familiar sight or a pleasant or arresting sight of beautiful objects upon which the eye can rest with pleasure, and by which the artist's eye can be educated. The effects of sunrise and sunset, and generally all beauties depending upon the atmosphere, are seen nowhere better than in a district such as this; everyone must have been struck occasionally with the grand cloud-pictures which may be seen in a country having a wide horizon—eccentric forms, Alpine snowy ranges, vessels, and whales, and every variety of hue: no lesson in colours can be better, and with such favourable lights it does not require much to make a picture: a twist in a river with a windmill, or a cottage, an old barge, a peasant, and a dog, will probably furnish the subject of a work of art.

Perhaps I may add, in speaking of flat countries, that they have in past times had an advantage over others in this respect, that they have got rich more quickly. Districts lying level with the sea, and intersected by natural highways in the form of rivers, with a rich soil ready for tillage, have generally been the earliest homes of art. The same is true in the painting of the water, which I think is a very important element in the encouragement of art; "money" is said to "make the mare to go," and it makes the artist's brushes and fingers to go too: artists of all kinds object to hunger, and unless there be men who are rich enough to be patrons of art, art is likely to wane.

To be sure you may sometimes find a man art-mad, like the famous architect of Palissy, who, I think, have had chairs, tables, bedsteads, everything, to keep up the fire in his furnace till his experimental pieces of pottery were sufficiently baked, and who got into scrapes with his wife in consequence which would have appalled a less stout-hearted man; and even Palissy, by-the-way, would not have been able to achieve what he did had he not met with influential patrons in the royal family of France. Money does not necessarily beget art; it may breed mere vulgarity and extravagance; still there must be wealth to enable people to patronise art, and there must be education to teach people to appreciate it, and those countries which rise early to opulence are likely to be amongst the early nurses of art.

And these considerations lead us to the remarkable growth of art in times gone by in those countries which we claim, par excellence, as the Low Countries—the Pays Bas—or Netherlands. If anyone wishes to know how high art can soar in low countries, he should observe what art has done in Belgium and Holland. We of the folks have, as I shall show you presently, some eccentricities which are not very complimentary concerning art here in this Isle of Ely; but if we are not contented with what we can find here at home, we may easily run over the sea and find, in a country very like our own, consolation enough to comfort the most weak-hearted. Will you kindly accompany me to Belgium and Holland for a very short trip, and as the G. R. Company has so many years so snug and comfortable by way of Harwich and Antwerp, will you consent to adopt that route?

As we steam up the Scheldt everything looks inartistic enough: mud-banks, the country as flat and uninteresting as our own; but on the land at Antwerp, before landing, we find a pledge of high art in the beautiful spire of the great church of Notre Dame. This is a wonderful piece of construction, and is enough by itself to make Antwerp worth a visit; very lofty, 380ft. high, but much more remarkable for its structure than its height; it is light as lacework, being in a degree the reverse of what we are accusstomed to in the proper sense of the word, but rather composed of pieces of stone clamped together with metal. The Emperor Charles V. is reputed to have said that it ought to be kept in a case. In my own humble opinion it is the most beautiful spire in the world; and I may add here, by way of parenthesis, that an additional stimulant to art is to be found in flat countries in the incitement which seems to be given to the erection of lofty buildings; when men have no mountains near them to dwarf their puny efforts, it is worth while to try how much of beauty can be gained for a building by the element of height.

The spire of Notre Dame at Antwerp is, however, merely the most conspicuous specimen of the art treasures of the old town. Even in the way of church art it merely stands at the head of a long list. But at Antwerp you meet with the masterpieces of Rubens, and with specimens of others of the most remarkable of Flemish painters. There is, perhaps, hardly any gallery in Europe of the size which contains more treasures and less rubbish than that at Antwerp; and, after all, it does not contain what is regarded by many Englishmen as the "Descent from the Cross," which hangs in the great church.

The mention of Rubens, the king of the Flemish painters, and one of the greatest painters of the world, makes it necessary for me to make a few remarks upon the Flemish school and its connection with the history of art. I am speaking to you of "High Art in Low Countries," and nothing is more remarkable than the contributions to the art of painting which have been made by both Belgium and Holland. Belgium did, in fact, invent the great art of oil painting for itself. It is true that the Flemish artists were not the first to use oil in the tempering of colours—Giotto and the early Italian masters were considering the method of oil painting before the end of the fourteenth century, but that the excellence of their method was such as to gain European celebrity, and to induce an Italian artist to journey into the Low Countries for the study of art, is, as the French say, impossible. Moreover, the excellence of the materials and the genius of the inventors speak for themselves in existing works. It will be sufficient to mention only which is perhaps their masterpiece. I refer to the picture, or rather series of pictures, known as the "Adoration of the Lamb"; part of the work is in the Church of St. Bevan, at Ghent; part is in the Musée at Brussels, and I have this list, and I am inclined to think it impossible to overstate the admiration which an examination of the work inspires; some of those to whom I am speaking have probably seen this great picture; for others it must suffice to remark that here we have a work in oil by the very inventors of the art, looking now, after nearly five centuries, as bright as when it came from the easel, and that of the crowd of saints represented as admiring the Lamb, containing several hundreds of faces, each finished with the beauty and perfection of a most elaborate miniature.

Who shall say that Low Countries are not good cradles for High Art? But the four Eycks were the beginning, and by no means the end, of the Flemish School. Of the Eycks immediately followed them, there are just two whom I will mention. The first, Hans Hemling, or Memling, for he seems to bear both names, and of whose brush there is a wonderful specimen in the Hospital of St. John, at Bruges; it consists of a large chest or reliquary, adorned with a representation of the legend of St. Ursula and her 11,000 virgins, who were martyred at Cologne, and whose supposed bones you may still see there. The finish and preservation of this work are wonderful; and they tell you at the hospital that offers have been made to the governors of a silver chest of the same size for that they possess in painted wood. The offer would be a poor one even in the more ground of gold value; for undoubtedly the visitors of Hans Hemling's work very soon contribute more silver than would be required to make the chest; and herein I may observe is to be seen an example of the royal prerogative of art, which can turn a few shillings' worth of wood and paint into a work absolutely more precious than silver or even than gold.

The other early Flemish painter whom I wish to mention is Quintin Matsys, and I do so not so much for the excellence of his paintings, though that is very great, as because he was by trade a blacksmith. Yes, blacksmith and painter:—nothing can be more singular. He always came to the easel with his tools in his hands, as anyone may satisfy himself by examining a wrought-iron canvas which protects a pump close to the great church at Antwerp. The story is that Quintin Matsys was in love with a young lady whose father objected to give his daughter to a blacksmith; so, for the sake of his lady-love, Quintin Matsys gave up iron and took to paint.
separable from the circumstances under which they were produced. Rubens, with his master, Otto Venius, and his pupil, Vandecyk, represent the Flemish school in its full manhood and perfection. A marvellous manhood it was! I feel myself incom- plete, and any business of art, and I know the value which belongs to my opinion, but I confess that the genius of Rubens impresses me as much as that of any painter whose works I have seen; you must not judge him by anything which we have of his in England, so far as I know there are but few examples. He can be seen in his glory, namely, Antwerp, and Munich; and when I see him in his glory, the freedom of his drawing and the magic of his colouring make you doubt which of the two is the more admirable. Woe to the unhappy painter whose works hang near to those of Rubens.

If we went no further on our tour I think we might say—Well done, Low Countries! But the Low Countries have done much more. There is no country in which art has been applied to the architecture of towns more earnestly and more successfully than Belgium. We English people are wonderfully thick-headed with regard to street architecture; we have no half-a-dozen towns which are tolerable, and of our modern towns the intolerableness is generally unassailable; only think of London and the large towns that are springing here on new streets and public improvements, and the small results obtained hitherto. However, it is not my business to abuse London, nor have I time to do so; my business now is to call your attention to the picturesque character of the Flemish towns, and, above all, to the influence of those towns upon the art of painting. The great towns were the centres of manufacturing industry, and where the inhabitants had plenty of money—for there was a time when the people had plenty of money, namely, when Ghent was the Manchester of trade, and when the English Government was obliged to go to the capitalists of Antwerp to borrow cash. It is satisfactory to see that our wealthy towns are now making efforts in the same direction; Liverpool some years ago built St. George's Hall, for courts of justice and other public purposes; and Manchester has just produced a really remarkable building for the accommodation of her lawyers, being probably the most successful modern application to civil purposes of the architecture of the Middle Ages, and having the general mark by the way, of England, and especially of England's great towns, in this department of art, is her smoky atmosphere. When Flanders built her Hotel de Ville she had plenty of money and a clear atmosphere: we have the money, but we lack the atmosphere; and what chance is there of first-rate ideas entering the brain of an architect when they are all to end in smoke?

There is one other branch of art which must strike everyone in travelling through Belgium, and that is the wood-carving. I rather mention this because we have imported a large quantity of wood-carvings from Louvain for Ely Cathedral; and suppose Ely Cathedral (if you have) will remember how much the effect of the stalls in the choir has been improved by the introduction of carved panels, exhibiting subjects from the Old and New Testaments. The principal opening for carving in a Flemish church seems to have been the pulpit; and some of the works of art in this department of sacred art are certainly wonderful. A pulpit, for instance, shall represent the Garden of Eden, and then you will have the preacher surrounded with beautiful animals, peacocks, birds of paradise, squirrels, &c., with Adam and Eve, perhaps, as large as life. It may be doubted whether some of these pulpets do not represent carving gone mad; but certainly the details are very lovely. You could be dead asleep during a sermon preached from such an exciting platform.

So much, then, for, Flemish art. In the superficial sketch that I have given, I have wished to impress upon you this conviction, that Belgium was one of the early nurses of art in Europe, and that it is impossible for anyone to pass through the Low Countries without thorough enjoyment, and that this is true; and the result, so far as we in the present day are concerned, is this, that here is a country, as uninteresting by nature as the Isle of Ely, or any other country of the kind, rendered positively delightful by the application of human skill to the highest departments of art; and, before I leave the Low Countries, I must ask you to observe that the same thing is true, though with variations, of the other great division of the Netherlands, namely, Holland. Did you ever go to Holland? If not, I am sorry for you. A visit to Holland of a few days supplies a man with recollections for the whole of his life. Of all the funny places I have ever seen, Holland is the funniest. It is the only country in which I have felt disposed to rub my eyes and pinch myself, to ascertain whether I was not in a dream. That is the only country in which I have felt the poetical height of the Spree could come and go. He was the son of a miller; and this, by-the-way, in Holland, is not a very exceptional thing, for it is a land of mills. Between Saardam and Woermeerveer, in North Holland, there are about four miles of mills, all planted by the side of a road as regularly as apple-trees by the side of a garden walk, so that one would say that there was a good chance for any Dutchman of having been born in a mill. However, Rembrandt was so born; and it has been suggested (I think very cleverly) that his peculiar style of painting, his method of lighting up his picture from one intense centre of illumination, may have been unconsciously suggested by the interior of his father's mill, where he played as a child. Certainly that occurred to me when I was in a Dutch oil-mill, watching the process by which two worthy Dutch millers were extracting oil from linseed, and when I noticed the dark interior, with the bright light streaming in through the open door, that there was a ready-made "Rembrandt." Thus Rembrandt is a geographical as well as a painter's and a glory of the Low Countries. Perhaps the most remarkable triumph of his art—and I refer to it because it is a wonderful triumph of art in general—is his picture, which you may see at the Hague, of a certain Professor Tulk lecturing on anatomy. Only conceive the trial of a painter's powers who is com- missioned to commemorate a famous anatomist by a picture subscribed for by his admiring pupils, and who undertakes to paint, not merely a head and shoulders, which in the course of two hundred years may stand for anybody, but the actual man demonstrating upon the dead human subject with his pupils around him! You may say the picture must be disgusting; but tell me what the picture of a portrait of art used by genius that even so strange and unappreciated a subject as a picture upon which the eye delights to rest.

At the Hague you may also see Paul Potter's bull—such a bull! so rinderpest about him: fine, wholesome young fellow, but his only topic of discourse and picture is life prevent him from walking straight out of the canvas, and treating you to a good loud bellow. To me, I confess, this world-famous bull is not so striking as another picture by Paul Potter representing a bear hunt: this is the most living animal picture I ever saw.

I trust a marvellous picture at Amsterdam by Van der Helst, sometimes described as the miracle of the Dutch school. It represents the City Guard of Amsterdam celebrating the Treaty of Munster: the picture has no great interest now, except as a remarkable group of portraits; here are about five and twenty persons, life-size, grouped together on one canvas, and each a portrait such as would make the fortune of an artist in London, while the action of each man is easy and natural, and the finish of the whole quite perfect.

These great pictures which I have mentioned are merely prominent specimens of a school. Painting has grown in the soil of Holland just as truly as her tulips and hyacinths: the brushes have not seemed to be derived from the Spanish and Italian, nor even of the German and Flemish; but it has done great things, and in imitative representative art, I need hardly say, it will challenge comparison with the whole world. My purpose, however, is not to institute an exact comparison between the Dutch and other schools of painting, but only to point out the moral and religious value of art. A country where the arts and sciences are raised to the level of high human wants, and has morally elevated, a country which, physically, is hopelessly low; and how it is true of Holland, as of Belgium, that a country naturally uninteresting has been endowed with charms of the highest order by the gifts of genius and the happy victories of art.

We must not linger, however, any longer in foreign countries. Time warns me that I must hasten to bring this address to a conclusion; but I must not do so without giving a moral, or what I should call in a sermon, a practical application. Let us
come home, then, to our own country, and let me remind you that, although we boast here of old school of painting, we may fairly say that in one department of art, and that a high one, namely architecture, we had, in olden days, a school in the Isle of Ely, of which the Isle may be proud. Ely Cathedral represents, as everyone will allow, Medieval architecture in the perfection of its beauty; but it may not have occurred to everyone who has admired the beauties of Ely Cathedral to think, or rather some may not have had the opportunity of knowing, that the principal Medieval glories of Ely, perhaps the whole, were home-grown.

I do not know the names of the architects of all the great works, but the architect of the most remarkable portion, the central octagon of Ely, and the studia, all the unadorned walls of Alan de Walsingham. I suppose from his name that he was not born in the Isle, but came from Walsingham, in Norfolk, a place in those days much more famous than now. He would probably have come from his native village as a boy to Ely, and would never have gone much beyond the bounds of the convent, except to see those farms of which he had the care as sacrist. But he was a man of genius, and circumstances favoured the development of his genius, though in a singular way. First he showed his love of art by making himself a goldsmith, and then he indulged the same love by turning architect. Many opportunities he found for the exercise of this art; in fact, the old church seems to have been constantly in his hands; he designed the Lady Chapel, he built that exquisite little gem which we call Prior Crawford's Chapel, and several other buildings of less note; but the grand opportunity for exhibiting his full powers occurred when the old central Norman tower fell in 1390. It is an ill wind that blows nobody any good; and though the fall of the tower nearly frightened the monks out of their wits and emptied their pockets, it was (as we say) the “making” of Alan de Walsingham. Never was there a better opening, and Alan perceived it: he did not send to London for Mr. Scott, as we, his degenerate successors, do, when we need any alterations or improvements, but he set to work himself; he determined that he would have no more basing, no more corners, no more towers, threatening to come down and keeping up a reign of terror, but he would recast the whole structure of the cathedral; and so he introduced that beautiful octagon which has been ever since one of the chief features of the building, and which may be reckoned amongst the prime results of Medieval architectural skill.

Here, then, we have close at home another specimen of high art in low countries: art, let me observe, none the worse for being consecrated to the service and worship of God; indeed, it is true as a matter of history, and perhaps we might have expected it to be so, that the religious feeling has been more successful than in any other in promoting the progress of art. Bezaleel, the son of Uri, and Aholiab, the son of Ahiram, of whom we read that God “filled” them “with wisdom of heart, to work all manner of work, of the engraver, and of the cunning workman, and of the embroider in blue and in purple, in scarlet and in fine linen, and of the weaver, even of them that do any work, and of those that devise cunning work.” Bezaleel and Aholiab were, I say, but the earliest specimens of a race of men who, under the old covenant and under the new, in the days of Moses and Solomon, and King Edward III., and Queen Victoria, have consecrated their artistic genius to the service of God. Here, too, if a man has power to realize it, is a spring of action which excites the bravest efforts and leads to the most transcendent results. You see the most complete illustration both of the power and of the success of the principle in the case of that most admirable painter the monk of Fiesole, whom it has become the custom to style Fra. Angelico: of him we read that he was a very clever painter for God, but that if he were made to him for a picture for any sacred purpose, he would ask permission of his superior, and then give himself to the work.

We have no artist monks in Ely in these days, but the ceiling of the nave of the cathedral may be taken as evidence, not only that there is art in the country, but the spirit which guided the brush of Frà. Angelico in Italy, more than 400 years ago, is alive in England at the present time. It is really a cheering fact with regard to art in our own country, that a work like that of the ceiling of Ely Cathedral should have been begun and completed by amateur hands. Most of you are probably aware that the painting was conceived and half-executed by the late Mr. Stenklem in-Strange, and that while he was engaged in his labours, suddenly and suddenly, the work was taken up and completed by Mr. Gambier Parry. I have no time to describe this beautiful work, nor is it necessary; anyone who can come to Wisbech to hear this address can easily go to Ely to see this painting; and I am sure that those who do see it—I may add, those who see the many other works of sacred art which are to be found in Ely Cathedral—will conclude that somehow or other, although we have no Alan de Walsingham amongst us, high art does still find its way into the low countries of our Isle. Long may this continue to be so—and may this industrial and art exhibition help to foster the love of art, and the knowledge that art is truly a gift of God; as Bacon, in the language of his latest and best editor, "declared with all the weight of his authority and of his eloquence, that the true end of knowledge is the glory of God, and the relief of man's estate," so also we may say that art has been given for the same great purposes, that it is intended to promote human happiness, and that it is used for its highest purpose when it is made to tend to God's glory.

All men are not artists, nor capable of appreciating art in its highest forms, but all men are benefited, more or less, by the progress of art; just as all men are not poets, and yet poetry softens the manners and polishes the mind, and makes this world more habitable for the most prosaic. You cannot tie up the benefits of art to a few—it is a gift to humanity, and extends in its influence and its blessings as widely as the human race extends; it may be abused to evil purposes, to mere luxury and effeminacy, just as other good gifts of God may be abused; but there is no reason why it should be. It is not to be compared, in point of value, with those other gifts which affect the absolute necessities of the body or the still more absolute necessities of the soul; but, putting aside these sovereign gifts of God, there is none for which we should give greater and continual thanks than for art, in all its multiform ramifications. We may see in it one of the most conspicuous proofs of God's goodness to his universe, that man has in this world, not only as a place to live in, but as a place in which the eye and the ear, and the whole mind may ever find abundance of beauty, and unceasing springs of delight.

GEOLOGY AS APPLIED TO ARCHITECTURE.*

By John Cumming, F.G.S.

The object of this paper is to indicate those points of contact between the geologist and the architect which must be useful to the latter and may not be uninteresting to the former. Some whom I address, no doubt, belong to what has been well-named the "Bricks and mortar school;" there may be others who are the slaves of mere aestheticism. The latter would be content with a sign, and if there were no practical necessity, no more than that, for the columns, the doors, and the walls, of the buildings, the construction of which is left to the contractor, who has no desire to make more than casts in the air they would consider their part complete. The former would ignore the art and sink the architect in the builder. To design in beauty, and not to rest content till he builds in truth, is the position asserted for the true architect. To enable us to build in truth a knowledge of materials which must be founded upon a knowledge of that phenomenon which is deduced from the drawing-office or on the building may readily be obtained. I cannot think that a knowledge of sciences, which provide the materials of which all edifices must be constructed, or which aid in their preparation, can in any way degrade or be beneath the notice of the true student; on the contrary, with the knowledge, however small, of geology, mineralogy, or mechanical science, the architect may, and often does, save large unnecessary outlay, and by so doing is in a position to expend money thus economised on such aesthetic details as may be congenial to his taste or in accordance with his preconceived principles. To that end, and from discussion upon the general subject, I trust, the remarks which follow will be of some interest, and that they may, in some small way, serve to indicate how the materials artists use is not beneath the notice of modern painters, and surely to understand something about the materials of which buildings are to be constructed cannot be beneath the attention of the modern architect, and geology will undoubtedly assist him in the investigation of stone, slate, marble, clay, cement, lime, sand, and gravel, for purposes of construction.

The science of geology has features which connect it with art in many ways. The late Mr. Richardson remarks:—"The

* Read before the Architectural Association, 1st June, 1880.
painter derives important aid from a science which teaches him the physical structure of a country and the principles which determine its scenery and aspect." Many works of great merit offend the eye by departure from the truth of nature, which a knowledge of geology would serve to correct. For example, how grave should we deem the error of the artist who, when depicting the coast of the Ionian side of our island, should sketch the scene with the rugged outline which characterises the primary formations of the north; or if, in representing an occurrence which happened in the northern district, he should delineate the angular outline of its Plutonic rocks with the undulating lines which characterise the sedimentary rocks of the south. Indeed, and of many other practical topics? This may in some degree account for the increasing tendency, in this very utilitarian age, to employ builders only, without the intervention of the architect. The builder-architect frequently possesses a large amount of practical information not shared in, by all events, the young architect. It will be admitted that the less the designer and the executer are united the better. The architect should not be obliged to bow to any man on practical questions which relate to his profession. Art and science are twins, each possessing a distinct path, but having converging lines and points of junction where they kiss each other and unite to speed a common work. If we aspire to the high place of M. Charpentier, we must have been checked from the absence of power to carry them out. Science, with a helping hand, has often stepped in, removed mechanical obstacles, and opened the road to higher art achievements. Greek science suggested the arch, Phoenician science taught the use of building-stone and its propagation; and it is necessary to admit the connection between art and science. Where so much that is beautiful in nature is made the basis of architectural ornamentation, a just appreciation of the objects selected as the basis of the design is essential. This is eminently the case where flowers or foliage are introduced, and, however, we may conventionalise, it must never be at the expense of truth. To avoid error, a knowledge of botany, however slight, is useful. To the artist it is essential. To be a good sculptor you must be an anatomist, and if anatomy be essential in the design of animal forms, equally so must botany be essential in the design of vegetable forms. In fine, it will be seen that whatever science be the basis of the structure of creation and the laws which govern natural phenomena should be hailed as an aid to place architecture in its legitimate position in the van of modern professions. Geology has been lately styled a popular science, but why I have failed to discover. It is true that many talk what is deemed geology, but their talk is far from it as the poles are adorning their eyewest with deceptive charlatanry. The error is with the public. To a geologist means to be well informed upon the nature of the materials of which the earth is composed, and to recognise by its contained fossils and mineralogical characters to what position in the series a given stratum is to be assigned; to ascertain the mode of accidental, and thus to recover them. The speculations too often regarded as deductions from such facts, are, in most cases, fallacies, not scientific inferences. The student-architect may employ some little of his time profitably in the study of geology. I do not ask him to give up his holiday sketching, his class of design, his life studies, &c. But he may discover considerable pleasure in the application of his own studies to the examination of geological features, and thus give an additional interest to his holiday reminiscences? In continental churches, monuments, and other buildings, may lie not found out of what stone they are built from, what formation obtained, the distance from whence conveyed, the age when used, their state of preservation, probable reason of their employment, and such other notes as may be suggested on the spot? Would not memorandum like these be of use to the profusion and yet be devoid of interest to
the geological world? To comprehend why the study of geology may be useful to the architect it is necessary to point out a few of the fundamental principles of the science. The present object is to awaken an interest that may induce some to look further into the subject and lead others to accept the work of the geologist as their own, and thus give it the study which it justly deserves.

The earth on which we live has for its upper crust a layer of materials, according to some four, to others six, or more miles in thickness. This is made up of different minerals deposited by the ocean, the river, the iceberg, and other causes, and altered in some cases, by chemical, in others by mechanical influence. But the earth is in a state of constant change, and the islands now dot the surface of the earth oceans and river once rolled, and at various times in the history of the world sea and land have changed places. These operations have been the work of ages, and each successive alteration has left its indelible mark on the sands of time. Tell a century ago the crust of the earth was considered a muddled mass of various rocks and soils with an incenscent centre; but since, by the patient study of Smith, the father of the science, Lyell, Murchison, De la Beche, and a host of other observers, both foreigners and English, the strata have been classified, and their relative chronological order ascertained, with an accuracy the most complete. The fossils, once thought to be the spontaneous generation of the earth, or the unsuccessful efforts of the Creator, are found, in the language of Mr. Mantell, to be the medals of creation, so much so that scarcely an organic remains is exhumed but it can be at once referred to its stratum, or at least the geological student.

In a natural history of England, published about seventy years ago, says Mr. Richardson, it is greatly observed, "that at Bethlehem, in Kent, a kind of stone is found full of shells, which is a proof that shells and the animals we find in them living; have no necessary connexion." Another amusing instance of the same argument is one of the last and most remarkable, that of the county of Surrey, in which it is stated that, in a search for coal near Guildford, the borers broke, and this was believed to be the work of subterranean spirits, who wrenched off the augers of the miners lest their secret haunts should be invaded. But the science has emerged from the incubus of superstition and is reduced to the foundation of facts. It has been demonstrated that each formation or stratification has a definite relative place in the series of rocks, as truly as a page has in a book, so that if a geologist sees a rock and ascertains by its mineralogical structure and its contained fossils its place in the series, he can procure in the general deposit a rock or chalk of similar character and age. Fortunes have been spent in the search for coal in places in which it could never have been found. Fortunes, therefore, might have been saved if their owners had been in possession of a few facts of geological science. Chalk for manures, stone for building, and many other substances, are obtained by two tons of chalk and the strata times be found beneath one’s feet. All the strata with which the globe is covered were, of course, deposited horizontally. The wearing action of the seas and rivers, the weathering of the surface by pluvial and atmospheric causes, and other disintegrating forces, have prepared the way for the transport of the materials previously consolidated, and the seas and rivers have been the transporting agents. It will be asked, if all stratas were thus laid horizontally, how it is that we are enabled to examine so many of them, seeing that the greatest depth which the miner has reached does not extend to a mile? During and since the deposition of the various beds of rock the earth has suffered very considerable volumes of granite, the most solid part of the earth have been cast down and the valleys have been exalted, strata have been tilted on their edges, and, like a pack of cards, overturned. Here we ride over the upturned edges of several formations, there we travel along the saddleback of only one upheaved stratum. The landscapes we admire, the hills of Shetland, and of the lowlands of England, are the results of such operations. Large as the convulsions may have been, and gigantic as their effects are, chaos has not been produced. If no upheavals had taken place, no depression occurred, all the mineral wealth of this and every other country had been hidden from view. Not only would the beauty of the earth have been lost, but we should have been without the materials with which art’s greatest triumphs have been achieved. Iron and coal would have been hidden in the bowels of the earth, and England’s greatest treasures undisclosed. Now the different beds of rock and other formations have, for the sake of study, been divided and named according to their position in the series. The old names were primary, secondary, and tertiary; now we have abolished the primary, and several other alterations have been introduced, but it will answer our purpose just to mention a few. The name granite was, as originally given to the geologist means granite, on the rock it more properly belongs to; it is the name given to a series of rocks which differ widely in appearance from that substance which is commonly known by the name of granite. True granite is composed of quartz, feldspar, and mica, but the proportions of these minerals differ considerably in the various granites of this kingdom. In some specimens quartz is predominant in others mica, and in many feldspar. The admixture of hornblende, hypersthene, actinolite, stelalite, tale, and other minerals gives a variety of names to compounds, we need not here mention. The flagstones and parapets of London and Southwark bridges give good illustrations of a felspathic granite, the crystals being large and well-defined. Micaeous granite is known by its glistening white or brown scales, and quartzose granite by the prevalence of that mineral. Included in the granite system are porphyry, serpentine, trap, &c. Fossils have not as yet been discovered in these rocks, but as they are considered the most enduring of all rocks, it is possible that the evidences of the existence of animal or vegetable life have been obliterated thereby. The recent discovery of a microscopic organism called the Zo Zooeum, in the Laurentine rocks of Canada, seems to tend to the belief that in time the existence of fossils even in the granite rocks will be determined. Granite and granite veins have often intruded themselves through granite rock of all stones; its advantages have been recognised in all times. It is distributed over the whole world. Egypt, Assyria, India, China present monuments which attest its excellence. In this country, Cornwall and Devon yield the greater proportion of granite used in England. The quarries are very large and accessible, and the stone is easily wrought. The Channel Islands yield a granite hard and good, but expensively wrought in preparation. Similar granite is obtained from Leicestershire. The choicest stone, however, comes from Aberdeenshire. The well-known Peterhead, with varieties of pink, yellow, and grey, is just now, comes from Aberdeenshire. In that district, however, the quarry is easily worked, and the cost of transit renders the employment of the stone, except for ornamental purposes, limited. Professor Ansted says that good granite has a mean specific gravity of 2.66, that the cubic foot weighs 108.5 lbs., and the cubic yard 3600 lbs., and that the stone is 'very durable.' Synite granite, in which hornblende takes the place of mica (according to Mr. Richardson), has been observed overhanging the chalk in Weinhollia, Saxony, and in Antrim, Ireland. Indeed, granite veins have often intruded themselves through granite rock of older date. These facts are given because we shall have to allude to the subject of granite as a building material, and to show that it is not all gold that glitters, and not all enduring granite that looks like it and bears its name. It is enough to mention, amongst the igneous rocks which are called volcanic in their origin, the names of greenstone, basalt, and tufta. A Greenstone is practically a variety of syenite, the composition of which I have given. It frequently passes into syenite, as is beautifully illustrated in the head of Romans, in the British Museum, where the body is greenstone and the head syenite. Porphyry, derived from the Greek word ϕορούς signifies pulse, and it is a term given to a rock of greenish colour, with the natural stone and an enduring one. It is found of various colours and textures. Lavaes are of different characters and bear various names, all, however, having the same basis, but having passed through different processes in their eruption or in cooling. Fylla is simply lava hardened up by the air, as dough is made open by carbonic acid. Tufta stone, a calcareous variety of which is found in Pembroke shire, is used as a building stone. Its durability, lightness, and freeness in working recommended it to the masons of ancient times for filling up vaulted roofs,
and there is no doubt that in the restoration of churches, where

time has weakened the foundations of arches, groined roofs, &c.,
it might, on account of its lightness, take the place of heavier

materials, especially in situations where the pressure upon it was
not excessive, it would appear to answer the purpose of the stones in

and purposes, stone. Of the metamorphosed or altered rocks
which are next in sequence I shall state nothing, except that from
them a beautiful crystalline limestone has been procured of the appearance of loaf sugar, and much prized for its purity by

the sculptor.

The Cambrian and Silurian rocks are the next important
division. These rocks form the elevated range from north to

south for nearly the whole of the western side of England, from
Cornwall to Cumberland, reaching the height of 3,000 feet, and
producing all the grand scenery of the lakes of North Wales.

The Cambrian rocks consist of slate rocks and conglomerates.
The slates obtained from the Cambrian system are well-known
from their exceeding smoothness, hardness, and fine grain
qualities, which, for building purposes, give them their pre-

eminent over slate from other and more recent formations.

Slate consists of successive layers of mud indurated by pressure,
and probably by chemical action, hence the ease with which it can
be separated into sheets of one of the coarsest of thicknesses. The
yield of slate can be increased to meet any demand. The use

of slate, ornamentally, has not received the attention it merits.

Mr. Mathews stated in his excellent paper on "Materials most
appropriate for London exteriors." that "slate is a material
that might be more generally used in a decorative manner.

Slate, when properly used in pavings, moulings, the colour is good and will harmonise well with stone and brick.

Enamelled slate offers a wide field for design.

The Silurian system affords us Llandudno flagstones and

limestones, some exceedingly fossiliferous and beautiful—plates

from Nature's book, illustrated by the originals, is, I cannot in

the remarks ventured upon which is called the Palaeontological

part of the subject, i.e., the description of the remains of

ancient life, however interesting, but I would remark that, in
the employment of stones for ornamental purposes, there is seldom

sufficient notice taken of the limestones which contain so many
beautiful specimens of Nature's handiwork imbedded in them.

It is true that now and then we see a mantel or chimney-jamb

of Derbyshire marble with beautiful examples of orridinarians or

orals; but might not decorative art utilize to a greater extent the

beautiful forms nature has afforded in these relics of the past?

The Devonian, or old red sandstone, so called from the red
colour it imparts to sheets of the most ancient rocks, is to be used in

pavings and marls, and limestones, amongst the latter some beautiful

coarline marbles. The sandstones are of all degrees of compac-
tness, and when of a slaty character are much used for heavy

roofing. The next in importance is the carboniferous, or

coal-bearing series of rocks. From these formations England

obtains her yields of steam—coal that is supplied to the boilers to

produce more than the value of the gold of Australia or California, or

the diamond mines of Golconda. Sandstones, shales, iron-\n
stone, millstone, grit, mountain limestone, and seams or basins of
coal, make up the system. The beds of mountain limestone are

estimated at about 1,000 feet of thickness; in these are found

in great abundance ores of lead, zinc, copper, barytes, and some
very fine marble, conglomerated, formed of the detritus of older
rocks of the magnesian limestone, and the dolomitic conglomerates
of Yorkshire and Durham. The latter are the beds from which
the stone used in the erection of the Houses of Parlia-

ment was obtained of which more by-and-by. I may just
remark, however, that as a building stone the magnesian lime-

stone possesses the softness and facilities of working of the

olite with the hardness and durability of the more crystalline
rocks. When highly crystallised it is termed dolomitic. The

new red sandstone, which belongs to this group of rocks, con-

sists of sand and marl, with pebbles of slate. The stone is too

loose and friable to be employed for buildings, and the only

feature of importance is the enormous yield of rock salt and briny

springs in this stratum. At Droitwich the salt rocks are the most

remarkable in that it is believed that they were worked by the ancient Britons, and for 2,000 years have been so at the

wash. With supplies to the coal-mine, the soil is held as a storehouse for the illustration of books it appears ominously filled.

By drawing on the surface of a block of chalk with a prepared
ink, which indurates where it touches, and with a brush
removing the intervening spaces of chalk which have not been
touched by the ink, an engraved block in relief, so to speak, is at once produced, giving with absolute faithfulness the artist's own touches. A stereotype from it may now be taken and printed as from an ordinary plate. The tertiary deposits above the chalk consist of sandstone, flint and limestone, crags, &c., and, lastly, we arrive at the recent accumulation on the surface. Thus, briefly, we have identified the rocks which previously constituted the crust of the earth, and in some measure have seen the application made of these rocks by man in the arts. To more than mention the chief deposits would be impossible within the limits of this paper. The question of the relative merits of these substances, the causes of their decay, and the means of their preservation, have occupied the attention of architects and men of science for some time past. It is no mean inquiry, for, next to the designing of beautiful edifices, the durability of the materials of which they are to be constructed occupies a prominent place. Our forefathers, whether by chance or skill in selection, in a great many cases appear to have adopted stone of a more lasting character than that employed in later times; and it is no small praise to them to acknowledge that, while buildings in this the centre of science and modern civilization have shown symptoms of decay after a short existence of thirty years, their best works, some of them executed for the indemnity of religious bodies of kings, for their temples, for the stores and winds and rains of centuries, and remain but little injured still. The reason why is the problem that can be solved in a great measure by the young architect of the present day in the way already pointed out: and I repeat, that to ascertain with accuracy the quality, the geologic age or formation, and the state of decomposition of the one or more enduring architectural works, is the first step, and to state the amount of decay, and the position in each building in which that decay has most shown itself, will be the best way to point out the rocks to be avoided and to suggest those that are desirable. Professor Asted classifies building stones under the heads of granites, sandstones, and sandstones, and the sub-divisions are those that can be worked only by the pick or by wades, and those that can be worked by the mallet and chisel, the latter being called freestones. Let us look at these minerals in their application to building purposes.

1st. Granites are not difficult materials to work with than granites; indeed, for centuries the architect rather shunned the strong material. Science, however, has come to the rescue, and by mechanical help great results are now obtained from the most refractory rock. While labour (that of slaves) cost nothing, granite, in early history, was selected for the immortality of kings, for their statues and temples, and for monuments of great events. Indeed, it was always employed in the erection of monuments that were intended to last for ages. In their choice of granite for these purposes the Egyptians were not mistaken. To this day the monuments of Egypt, my, the hieroglyphs on their bases, and the stone itself, has survived in a manner and still preserved. The cost of working, however, is still great, but as this cost decreases, as in time it must, we shall see more of it used in architectural work; not in the servile manner in which it is now the fashion to employ the red granite of the north, but in numberless instances where the wind and rain beat, and where it is so admirably adapted to withstand these influences. In this way it might prove a permanent and enduring assistance to buildings composed in other parts of more perishable materials. Granite can now be obtained of so many different shades of colour that any building stone can be found to harmonize with it easily. The sculptor has tried to employ granite in this respect, but its mottled appearance and often faulty composition are sadly against it for his purpose. It is needless to quote churches and buildings in this country in which granite has been employed in past ages. Nearly all of them show no symptoms of decay, but in some instances disintegration or decomposition has taken place from the action of water. Examples of undisturbed samples of stone, as it appears that there are some granites no more proof against the weather than the poorest limestones. Hard and compact as granite appears, it is, nevertheless, sufficiently open and porous to admit a considerable amount of moisture. By absorption it will take up nearly 1/3 per cent. of water, where disintegration takes place, it is owing mainly to this circumstance. In all stones that admit water, and all do, frost employs its terrific force and separates particles after particle till the surface is destroyed. Water conveys the

chemicals which exist in the air to the interior, and by its solvent power, due in a great measure to the carbonic acid it contains, decomposes all stones. To judge of the great power exercised by carbonic acid as a solvent, it may be mentioned that all the silice that exists in the vegetable world (and no plant can grow without it) is derived from the stones and flints of the earth, and absorbed by the microscopic capillary cells in the roots, but the solid silice could not pass through these cells and water, we know, will not dissolve flint. How then is it to be accomplished? The rain that falls collects the carbonic acid of the air, and acquires the same from the soil through which it passes, and in combination with it dissolves the flinty rock and stone, and thus conveys the necessary support to the roots of all vegetation. In the selection of granite for enduring purposes those in which the constituent minerals are most evenly proportioned are the best. Like small paving stones, each particle seems to help the other, and the smaller the grain the more completely is this the case. Large crystals of feldspar are always objectionable on account of their readiness to decompose. For ornamental purposes almost any granites are available, many affording very rich combinations of colour, and if the surface be polished the weather has less hold upon it and it lasts longer. If granite be totally submerged in water and not decomposed it will last, standing that water alone, without the agency of the air and decrease of temperature to the freezing point, will not materially affect it. The feldspar of granite is the most likely to decay. The well-known kaolin, or China clay, is nothing more than decomposed feldspar, a material which exists largely in Cornwall and Devonshire, from which two counties 60,000 tons were exported in the year 1865.

*(To be concluded in our next.)*

**Review.**


**Second Notice.**

In introducing the subject of steam fire engines Mr. Young says, "The manufacture of steam fire engines in England, as a regular branch of industry, is of very recent origin; and although to England belongs the honour of having made the first steam fire engine so far back as 1829—when it was constructed by Mr. Pole and Mr. Mothers, and exhibited in London, by which no more were made at a later period, all being eminently successful,—yet, so strong were prejudice and other influences, that from 1832 to 1852, no more were made in this country, nor was public attention directed to the matter." That this should have been the case in a country professedly so practical, and disposed, in all instances, to treat things simply upon their merits, would be absolutely incredible, were not the fact patent to all who have taken the trouble to inquire into the subject. Unfortunately the late Mr. Braidwood, although undoubtedly a thoroughly clever and practical man in the handling of the then ordinary appliances for fire extinction, was prejudiced in his views regarding the introduction of novelties, such as the substitution of steam for manual power, and we cannot but think acted towards the real pioneers of improvement, Messrs. Brathwaite and Ericsson, with some injustice.

We quote the following plain but suggestive remarks from Mr. Young's work: "The late Mr. Braidwood was, from the beginning of his career in London until within a short period of his untimely end, most strenuous and determined opponent of steam fire engines, 'because they were expensive,' and there 'was not sufficient water to supply them.' Therefore, although 'admitting their great efficiency, they 'were out of the question until a larger supply of water could be obtained, and then his impression was, that when they came to have an adequate supply for steam fire engines, a higher pressure could be given, so that they could work from the main without requiring the steam fire engines!'" However, after all this, when the con--

* See infra, p. 188.
struction of steam fire engines was revived in England by Messrs. Shand, Mason, and Co.—who made their first steamer towards the close of 1868, and constructed one in 1869, which was hired by the London Fire Engine Establishment—we find that this engine seems to have been viewed with peculiar favour; for Mr. Braidwood wrote of it: “That at large fires, beyond the reach of the steam floating engine, the land steam fire engine has been of great service. It is not only the large quantity of water which it throws (!) but the height and distance to which it is thrown which makes it so valuable. At the same time it can be worked as gently as an ordinary engine.”

“It is curious to find that the objection so persistently urged against the use of steam fire engines from 1829 to 1856, viz., that they threw too much water, should in 1860—2 be esteemed one of their chief advantages; and that, too, by their most strenuous opponent! It is difficult to assign a reason for this, since fires were no heavier in those days as at the present, and certainly as likely to require a large body of water then as now. After this we find Messrs. Shand, Mason, and Co., the ‘sole steam fire engine makers’ to the London Fire Engine Establishment; at least, such is the case practically, as no other maker has been favoured with an order to construct them a trial engine; and when one was offered on loan by another firm, it was declined. From this we should infer that the ‘Establishment’ did not desire to find out or employ the best engine, but to keep up and maintain a close monopoly in steam fire engines with their favoured makers, regardless of the results of practical working or improvement; and by this course cannot be said or considered to do or have done anything towards settling which is the best steam fire engine.”

It would not doubt be a matter of some difficulty to fully explain the causes of Mr. Braidwood’s marked change of opinion here adverted to, and his subsequent persistent patronage of one firm only. Very possibly, however, there were in this case, as we well know there have been in numerous governmental departments, influences at work which led him to judge with different eyes to the public at large. Be this as it may, it is very certain that, whatever its merits or demerits, Messrs. Braithe and Ericsson’s engine was set aside on grounds which were subsequently put forth as advantages in respect of an engine by other makers; and we cannot but sincerely regret that when a change occurred in Mr. Braidwood’s opinions, he did not at once allow those gentlemen a sufficient opportunity of competing for the business to which, in so far as we can judge, they were justly entitled. Their first engine (Fig. 4) is thus adverted to:

The application of steam power to work a force pump, arranging the engine, boiler, pumps, etc., on wheels, so as to be easily portable, and thus enable it to be readily employed as a fire engine, was first carried out in the year 1849, by Mr. John Braithe and C.B., of London. In this year he constructed, at his works in the New Road, in conjunction with Mr. Ericsson, an engine of 10-horse power, with two horizontal cylinders and pumps; each steam piston, and that of the pump, being both attached to one rod. The waste steam from the cylinders was conveyed through the tank containing the feed water by means of two coiled pipes, thus giving the feed water a good temperature previous to its being pumped into the boiler. Fig. 4 is an engraving of the engine made from the drawings, under the superintendence of Mr. Braithe himself, as were all the engravings of his engines. Its weight complete was 45 cwt., and it threw from 30 to 40 tons of water per hour to a height of 90 feet, having thrown well over a pole that height. During its five hours’ working at the fire at the Argyll Rooms, it threw well over the dome, and consumed 3 bushels of coal. This engine worked with the greatest success at the fire at the Argyll Rooms, at Charles Street, Soho; at the burning of the English Opera House, and Messrs. Barclay’s Brewery, besides many others of less magnitude; at all of which it rendered signal service in preventing the fire from extending. For these gratuitous services, and the great outlay encountered by Mr. Braithe, he received but little patronage and support from the general public; and from the insurance companies, who must have benefited to the extent of some thousands of pounds by his exertions, he received the magnificent testimonial, presented to his men, of One Sovereign.

Immediately after the fire at Messrs. Barclay’s brewery, the engine was lent for several weeks to be employed in pumping and starting the beer from the different vats in the establishment; a duty it was performed, having to be kept at work day and night for one whole month, which it did without the slightest hitch throughout that period.

During the fire at the Argyll Rooms, the cold was so severe that the manual engines quickly became frozen and useless; but the steamer worked incessantly for five hours without a hitch, throwing its stream clean over the dome of the building.

Mr. Young says, “In 1869 Messrs. Shand and Mason con-
constructed their first land steam fire engine, on the patent of Mr. Stodd, which was sent to Russia. The engraving (Fig. 5) is from the patent drawing, which shews the general appearance of the engine.

**Fig. 5.** Shand and Mason's First Engine, 1869.

It is thus described in the specification:

According to this invention the steam cylinder which actuates the pump is inverted, and situated over the air vessel of the pump, which is made double acting, one barrel being placed above the other, and a double throw crank is placed between them. One or both of the pistons or plungers of the pump is fitted with a valve, and the piston rod of the steam cylinder is connected directly with the piston of the upper pump barrel, which latter serves as a guide to the piston rod of the steam cylinder. A connecting rod from the upper pump piston connects it...
with the crank, while a second connecting rod connects the piston of the lower pump barrel with its throw of the crank. The slide valve of the steam cylinder is worked from eccentrics of the crank-shaft outside the pumps, and the lower pump barrel is enclosed in a suction air vessel, fitted with a separate valve if necessary. A fly-wheel on the crank shaft and a feed pump are placed near the boiler. The whole is supported on a carriage consisting of a suitable framing running on travelling wheels, and furnished with springs and a locking carriage. In the course of an upright boiler, the steam pump being situate vertically between the front and hind axles, and behind the driver's seat. Beneath the seat is placed the hose reel, or a box for containing the hose and implements.

The horse given is not such as to enable any very exact idea to be formed of the engine: while the boiler, which is certainly a point of the most vital importance, is not described at all; neither are there in this case any results given of the engine's performance. We find none of the usual notes, so as to have anything as to weight, or other construction by Messrs. Shand and Mason in 1859, very fair results as regards jettie thrown are said to have been attained. After telling us that in the year 1860 Mr. J. Shekleton, Dundalk, constructed the first steam fire engine ever made in Ireland, the author proceeds,—"In July, 1860, a land steam fire engine was for the first time used by the London Fire Engine Establishment in one of the back streets of Doctors' Commons. In point of 'efficiency, simplicity, durability of parts, weight, and cost,' it was an improvement superior to Mr. Brainwhaitse's steam fire engine of 1829, while, in some respects, it was inferior to it. In a Report to the Committee (the late Superintendent of the Brigade admitted that this engine 'required delicate handling;' and so unsatisfactory was the whole of its performance that at the end of ten months it was withdrawn, and replaced by one of a different construction, bearing a closer resemblance to that of Mr. Brainwhaitse. It is learnt from the evidence of the present Superintendent of the London Fire Engine Establishment that the weight of this first steam fire engine, with one, coals, and water, ready to run out, was 86 cwt., 4 tons 4 cwt., and that it took three horses to draw it.

The various steps in the progress of steam fire engine manufacture thenceforth are most carefully noted, including the production of Mr. Roberts's "Lucy," the floating steam fire engine constructed by Messrs. Merryweather and Sons for the warehouse of the Tyne Docks, from the designs of Mr. E. Field, C.B., the "Deluge" land steam fire engine constructed in 1861 by the same firm from designs by the same gentleman, three steam fire engines in the same year by Messrs. Shand & Mason, to run on the rails of the London and North Western Railway and numerous others, but which our space will not permit us more particularly to notice in the present number. We subjoin engraving and particulars of the "Deluge," and hope in our next to continue our notice so as to enter into the discussion of some of the questions treated by the author.

In 1861, Messrs. Merryweather and Sons constructed, from the designs of Mr. E. Field, C.B., their first land steam fire engine, the "Deluge," which was a perfect success. This engine was of 30-horse power, and had a single horizontal cylinder 9 inches in diameter and 10 inches stroke, and a double acting beam 6 inches diameter 15 inches stroke, working over the piston rod of the steam cylinder, doing away with crank, fly wheel, connecting rod, &c.

Fig. 6 is an engraving of the engine. This engine has thrown water through a nozzle of 1½ inches, 10 feet over a chimney, 140 feet in height, altogether 160 feet; through a nozzle 12 inches to a height of 167 feet; through a 1½ inches to a height of 175 feet; through a 13¼ inches to a distance of 302 feet horizontally; and through a 1¼ inches 315 feet horizontally. (To be continued.)

STEAM POWER DOUBLE WITHOUT ADDITIONAL FUEL—IS THIS POSSIBLE?

To the Editor of "The Civil Engineer and Architect's Journal."

As progress in the arts requires us to advance from empirical and partial to scientific and extensive knowledge of almost occasional recurrence to first principles, if not always requisite, is often indispensable. For lack of appealing to them, errors, and oversights equal to errors, are apt to become established, till their real character is not suspected and hardly believed when pointed out. So it has ever been and will be. Referring to heat and steam sugar, a writer announces that the juice of the cane contains double the quantity of saccharine crystals extracted from it—that quite as much is lost in the primary manufacture as reaches the market. Passing by other examples of thoughtless waste, the same may be said of a product vastly more important to commerce and the world at large than the richest of saccharine plants—steam power. Of it the high-pressure or non-condensing engine is the popular representative, and strange to say, the first positively controllable the amount of power which the engines draw or ever can draw out of it. Hence, if operatives of the last century are rightly considered dullards for wasting materials, what in the next one may not be said of us who, after evolving with costly apparatus the most valuable of motive agents, discharge it into links and scoters, or the air, with half its power education. Once the waste does not come from the wrong cause, the mill of refuse or alloy. Expert and alert we as in many things, we surely shall not be thought adown in economising which gives value to every material.

But are there not engineers who deny that anything like so much power is lost in waste steam? Yes, I think all with whom I have conversed emphatically dissent; and yet the fact appears as clear to other minds as that they exist, and, furthermore, that the alleged amount, so far from being an exaggeration, is largely under the truth. Doubtless the views of practical men should command respect; but crucial tests and natural laws, not human, cannot be dispensed with. We have been as it were deceived because not deemed worthy the trouble of clearing up, but in a matter of such importance to advancing civilization as this it ought not to be left an hour in uncertainty. Nor need it be.

The subjoined propositions cover the whole ground, and what follows them will, it is presumed, suffice for their demonstration. It is all one which we suppose the discharge steam as it imparts to the piston, however great that may have been. 2. In most cases more power, and in some cases double the power, may be obtained from it.

As I wish to address others beside professional men, a preliminary observation or two will not be out of place; for, though the subject is becoming an item of college education, few look into it, and general ideas reach little beyond the external features and movements of an engine. There is no reason why this should continue, nor will it, since whatever is uncertain about steam vanishes when thoroughly looked into, and every person of ordinary capacity can do that. Its properties are as palpable and plastic as those of other bodies. It is weighed in the same scales, and its quantities ascertained by the same measures as liquids and solids. A pound of it is a pound of water vaporised. The mode of using the measures is somewhat different, but not less rigid and correct. One holding a cube foot of water has to be emptied and filled afresh till the number is reached; whereas we can look into the engine, and generally contained in the space of one, the number being indicated by the pressure—hence pressure and quantity are complement and explicatives of each other. As volume increases pressure diminishes, and vice versa, the quantity remaining the same. The smaller volume may comprise the larger; thus five cubic feet of the former processes, but to the volumes discharged from 40 to 20 tons, or twenty feet of 10 lbs., all three equivalents in cost, weight, quantity, and power.

These remarks are introduced to enforce the imperfectly acknowledged truth that the power of steam is increased only by increasing its quantity, just as more heat is obtained by consuming more fuel, more light by turning on more gas, and as the force of a gun is increased by adding more powder to the charge. Hence, to double or treble the power of steam in a boiler, double or treble the quantity must be generated in it, for there is no increasing the natural force of the fluid. As a source of mechanical power the atmosphere is little thought of; and still less as the recipient of all forces—Nature's receiving and reacting reservoir. A perfectly clastic medium, it softens the effects of the most violent, and responds to the smallest. To say nothing of natural forces, which, as in the case of wind, inconceivably minute fractions only have been used, the steam internally rising from human application of heat to water, if cooled under pressure held at a productive power equal to the muscular energy of multiplied millions of men and horses, while we of the present age are responsible for recklessly contributing vast additions to the waste. I do not allude to what ascends from domestic habitations and manufacturing processes, but to the volumes discharged from motive engines by those whose profession it is to apply force, and the best proof of whose skill is to economise it. What inference can hereafter be drawn from our employing the force that
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

expands a volume of water into 1,760 volumes of vapour, and neglecting that which is evolved by the shrinking back of the 1,700 into one. What, but that the fact was either not known or overlooked that the negative force in fluids is equal to the positive.

Nearly all the world knows that a cylinder of steam is discharged from a high-pressure engine at every stroke of the piston; and that from the motion of the strokes and the high temperature of the fluid, little is lost in passing through the cylinder. Now, does every puff of the escaping vapour contain or not an amount of power equal to that it imparted to the piston; in other words does its shrinking back into water give out power equal to that which raised it out of water, and just as fully as a falling weight gives back that which raised it? The answer has just been anticipated, for the question is nothing less than an appeal to the law which governs every form of force and every mode of application—the fundamental law of action and reaction. According to it the two forces are absolutely and inevitably equal, for one to be less than the other. They are simply contractions and expansions, equal and opposite to each other. To exemplify: A high-pressure engine has a piston of the area of 60 square inches, and is worked with steam, say of 90 lbs. to the inch, hence 60 x 60 = 3,600 lbs. of steam pressure. Now if the fluid, instead of being discharged, were condensed under the piston, it would produce precisely the same result; thus, steam of 90 lbs. contains four volumes of common steam, and would dilate and fill a cylinder with a piston of 200 inches area, both cylinders of one length; hence its condensation would excite an atmospheric pressure of 200 x 16 = 3,000 lbs. So much for the first proposition.

If the second be thought to conflict with the first it only appears so. A cylinder of common steam has no expensive force or direct action on a piston, but is all that is required to produce a vacuum under one; so that while the two forces are theoretically equal, the contracting one is practically the most productive. More power—16 lbs. on the inch more—is obtained by condensing steam of 200 lbs. pressure and applying the atmosphere of 107 of the steam, than by the same direct action on one inch of the atmosphere, and therefore loses (expenditure without return) 15 lbs. on the inch, while the contracting one, coinciding with the pressure, gains that much. Hence engines working with 90 lbs. steam, or a pressure of two atmospheres, give out only the force of one; whereas 160 lbs. steam, the force of two, and so on. The term “most cases” in the proposition might be changed for “all cases,” and the “some cases” scarcely needs a formal exposition. An engine with a piston of 50 inches area, and using 30 lbs. steam, has, of course, an available force of only 16 lbs. steam; hence 50 x 16 = 800 lbs. steam pressure, but the same steam, when expanded under a piston of 100 inches area would yield double that amount in atmospheric pressure; it would be 100 x 15 = 1,500 lbs.

Perhaps it will be said this is no new discovery. Granted; but it is a great truth, nevertheless, and one hitherto overlooked or not appreciated. Adopt it and it will be found surpassingly more effective and profitable than the numerous wire-drawings of subordinate devices.

What is the expense of thus saving waste steam? As the force of a high-pressure engine is deemed to be worth much more than the fuel it costs, an equal additional amount should be held cheap at the same price. Instead of that, however, it is offered much cheaper than water is cheaper than coal. The expense consists in the application of that which may almost everywhere be had for nothing. To decline the advantage offered is to prefer partial results at a great cost to full results at a smaller one; but when the superior productiveness of the shrinking over the swelling force becomes generally known, it will scarcely be much longer neglected. With the denser, the judgment that consigned Newcomen’s engine to desuetude will have to be revised.

To save steam power is to save that which is more valuable than silver or gold. To be careful of evolving and parasitical in expending it is a virtue—to waste it, a crime. Its economy has relatively increased during the last quarter, and the former wooden bridge which was entirely swept away by the great flood of the previous March. The whole bridge cost less than 40,000 dol., and its construction occupied about four months. The cables supporting the structure festoon the river, as it were, in five spans, each 200 feet in length, the intermediate towers resting upon the masonry of the former piers. The general plan of the bridge is known as the “Murphy Military Suspension Bridge, U.S. AMERICA.

By ALFRED P. BOLLES, C.E.

This bridge crosses the Susquehanna River at the foot of Market street in the above city, and at a point where the river is nearly 1000 feet wide. It was thrown open for travel during the beginning of the last year, and has greatly increased the commerce and business of the place.
Bridge," embodying some marked improvements and advantages which will appear further on.

The Cables, having a common versed sines of 20 feet, consist of five wire ropes for each side, of an inch and a quarter diameter, and are continuous from anchorage to anchorage. They were hauled over from one side of the river to the other by teams of horses, and secured on the towers by ordinary block and tackle. The whole ten were stretched over the river and adjusted to place in little less than a week's time. The ends of the cables are secured in forged wrought iron thimbles, the wires being frayied out by means of tightly driven spargis, the interstices remaining filled by the least thick iron shot. The thimbles are connected with the turn-buckles, which are 18 inches long, by means of forged iron and three-quarter bolts, with eyes on one end, and screw-heads at the other. The turn-buckles screw upon 2 inch rods, which pass entirely through the masonry.

The Anchor Masts. At about 40 feet above the foundation proper, a trapezium in form, 15 feet long in the line of slope, the front face being 8 feet 3 inches high, and the back 2 feet 8 inches. Upon this slope the anchor iron, consisting of five 2 inch rods, were laid, and solid masonry 3 feet high built upon them. The uniform width of the anchorage is 4 feet 6 inches, and is built of heavy flagging stones, 6 inches thick and upwards, and is thoroughly grouted from top to bottom. Each anchoring mass contains thirty-six perches of masonry. The pressure is distributed over the masonry by means of four vertical 7 inch Phenix beams, against which and at their centre two parallel and horizontal 9 inch beams bear, separated enough to let the ends of the 2 inch rods pass between, and cast iron washers, for the nut to be screwed up against, complete the fastening.

The Towers, 27 feet high, supporting the cables, are in the form of a frustum of a pyramid, battering at the rate of one inch to the foot. They are built of white pine 12 × 12 posts, mortised into their foundation walls, and 14 resting upon the tops of the piers and abutments, which posts are connected at proper intervals by ties mortised into them. The hollow spaces between the sills and ties are filled in with cement masonry. These sills are continuous, i.e. each pair of towers is framed into the same set of sills. The legs of the towers are stiffened by having ties mortised into them and pinned with oak pins. The caps are mortised into the tops of the posts, the shoulders of the mortise being made square with them. Resting upon these caps are the saddles, also of white pine, in three pieces; the centre one of which (16 inches deep) is bolted into each cap by one inch bolts. Each pair of towers are united together at the top by means of 18 tie beams, bolted to the under surface of the caps by means of the same bolts that secure the centre saddle pieces. An inch and a half bolt passes through each pair of caps for attaching the truss rods to.

The Roadway is 18 feet wide in the clear, and is attached to the cables by means of white pine posts, 7 inches square, hinged together in pairs, with an inch space between them for the truss rods to pass through. These suspenders are so arranged as to divide each span into ten panels, all of which are 20 feet from centre to centre. These suspenders have a slightly greater batter than the legs of the towers, so as to slope towards the chord line of the cables when freely suspended. The cables are spread in pairs over the towers, but gather at the suspender passing between them, and bear against oak saddles sunk into daps in the posts, and an inch bolt passing through both posts and saddles completes the attachment. Nine inches from their lower ends, the posts are clasped by two floor beams, 8 × 14 each, bolted to them, and running far enough past the posts to support foot-walks on either side. These floor-beams support the stringers.

The outside stringers are packed chords, bolted to the floor-beams, and are packed in two pieces breaking joint, each piece being 5 × 12 inches scantling. There is one joint for each panel, which joint is always over a floor-beam. The three inside stringers, one pair of which is shown, and between them in the upper series of bolts that fasten the floor beams and the posts together, to which they are attached by means of an eye, and through which the above described bolts pass. At the point where they would intersect, they are cut off, passing into ring of half-inch flat iron, against which the ends are screwed up and adjusted. The truss rods pass between the pairs of suspension posts, and are all of one inch round iron. For three panels each way from the towers, the tops and bottoms of the suspension posts are connected directly with the bases and tops of towers. The rods of the last panels (those that incline downward) are secured on the opposite sides; in other words, they pass through the last posts of the towers, and are screwed up against the legs on the further side. They thus act as an additional tie and stiffener for the bases of the towers. The ends of the truss rods are screwed up against oak blocks, bearing against the floor-beams and the feet of the suspension posts, to allow for the stretching of the cables, a number of 12 inches for each span was framed into the bridge, and adds very much to the general appearance. It is intended eventually to put the foot-walk on, to pass through the towers and provided for in construction in the elongation of the floor-beams. The railing will be a substantial Howe truss 6 feet high. At present the bridge is subjected to a heavy amount of traffic, such as stone, lumber, cattle, etc., and it gives evidence to a surprising degree of stiffness due entirely to the peculiar system of trussing, in making the verticals act by thrust, and the diagonals by tension. This general arrangement for suspension bridges was first practised by Mr. John Mylne, of London, and also at Philadelphia, Pennsylvania. But he used his diagonals to truss each panel separately, instead of trussing panels by attaching the diagonals to fixed points, as is the case in the above described bridge, where the diagonals are secured to the towers for six panels out of ten in each span. Without the aid of the trussed railing, the effect of a heavy team passing over the bridge can hardly be felt until it strikes the span that we may be standing on, further than the slight tremor inseparable from all bridge superstructure, especially those of the suspension class. Without considerable modifications, the above construction for suspension bridges is incapable of spans much above 200 feet.—Franklin Journal.

New Arrangement of Bar Vice.—At a recent meeting of the Franklin Institute of Philadelphia, a new arrangement of parallel jaw or bar vice, the invention of Mr. Linus Yale, was described. This tool is designed to obviate a difficulty existing in all ordinary vices, the jaws of which are moved by a screw, viz.: the time lost in opening and closing the jaws by the tedious process of turning the screw. In some kinds of work, such as, for instance, as the manufacture of locks, the ease of the lock requires to be held edgewise, and then flatwise. This necessitates the jaws being opened through considerable distance, and then closed as each change is made in the way of holding. Mr. Yale, in noticing his workmen at this kind of work, found that 12 per cent. of their time was consumed in opening and closing the jaws of such a vice. His invention consists in having a nut and screw with the bar, as usual, but the nut is not attached to the bed or the stationary jaw of the vice. To this jaw, in the under part of the guide, is a rack with ratchet teeth. The nut is square, and has teeth on its under side corresponding to the teeth in the rack. The nut, when screwed to the back end of the bar, rides upon an inclined plane, which so elevates it above the rack, that its teeth cannot engage therein. In this position the movable jaw can be pushed back and forth, i.e., opened or closed rapidly by hand without turning the screw. Placing a piece of work in the vice, as, for instance, a piece of wood about three-eighths of an inch thick, the jaws can be pushed quickly up to it, and then one turn of the screw draws down the nut into the rack teeth, and a part of a turn will secure the work as firmly as if screwed in an ordinary vice. The same amount of back turns of the screw release it, and then the jaws can be opened wide to receive the block edgewise. With about three inches open, one turn will again close it. The vice can be used in any position, by drawing out the movable jaw to any required distance, and then screwing it all the way home. It will, within the range just referred to, act as if the nut was fast to the stationary jaw. The rack in this vice is not rigid. It has a spring back of it so as to allow of pressure being supplied to allow the workman, when filing to a template, to adjust his tool to the template, and then enable him to move the template, and adjust his tool to the template, and then enable him to move the template, and adjust. Workmen will appreciate this; for they are aware that in a rigid vice the work must be either very fast or very loose.
St. Andrew's College, Bradfield.
With the Proposed New Library, Studies, and Schoolroom.
PUBLIC MONUMENTS IN BELGIUM.

The Belgian authorities exhibit great regard for their public works of art and monuments. A central commission is entrusted with their keeping and also with the consideration of all questions, theoretical as well as practical, touching their preservation. The report of the proceedings of this commission, embracing rather more than twelvemonths' labour, has recently appeared, and deserves attention.

It appears that the commission has more than twelve hundred subjects before them; that the project for the restoration of public works was presented to them included nearly two hundred; and that the works undertaken in consequence absorbed nearly £20,000. In addition to this the commission had to examine more than two hundred other projects for new buildings, and a still larger sum was expended on that account. The funds to meet this expenditure were contributed partly by the Government and partly by local authorities.

The report refers to the efforts made by the commission to clear away all buildings abutting on churches, as a precautionary measure, as well as in the interest of art. It was found on inspection that the inhabitants were in the habit of cutting away buttresses, undermining walls, and injuring foundations by the sinking of wells.

Under the head of the decoration of religious edifices the report mentions the discovery in many churches of old mural paintings, covered up for long years beneath coats of paint or whitewash. Extensive decorations are proposed to be executed in old buildings, and more extensive ones at Bruges and at Quaregnon, and a new extension of the museum at Antwerp is to be commenced next year. Amongst other useful services done or proposed to be done are the creation of a special atelier, under the auspices of the Government, for the restoration of ancient paintings, the formation of a complete catalogue of the works of art existing in public buildings, and the repair of the old gates of the town of Antwerp.

An interesting portion of the report is that which records the discussion by the members of the commission of several important questions submitted to it by provincial committees in communication with the central body. The Committee of Brabant proposed, first, that every artist submitting a plan for the restoration of a monument should be required to furnish a memo in support of his proposal; and, secondly, that in the case of new buildings the commission should confine itself solely to the consideration of the estimates and the solidity of the construction, leaving the entire responsibility, in an artistic point of view, with the artist himself. It is not surprising that the novelty of the proposals should have met with considerable opposition, and that the opinion of the majority was adverse to both; it being argued against the latter that the commission, in renouncing all control over the esthetic value of the plan submitted to it, would be giving up its most important prerogative. It should be mentioned that the commission is only empowered to discuss the subjects submitted to it, the decision being left to the Government. Another proposition was that a series of general instructions should be drawn up on the restoration and preservation of public monuments, and transmitted to all the administrations charged with such duties. This subject was discussed at length. One member considered that the reproduction of the very complete instructions published in France by the Committee of Monuments would be all sufficient. In opposition to this it was argued that Belgium was in a peculiar archaeological position; that she was, as it were, at the confluence of various styles, and the restoration of many of her monuments would present many points which had not been provided for in the French instructions; that many excellent architects were not archaeologists; and it would be useful therefore to establish certain general rules for the restoration of monuments in different styles; the architect who planned a new building should be left absolutely free, but it was not so when the restoration of an ancient monument was in question; in such a case his duty was to conform rigorously to the idea of the author of the work. The provisions of the proposition argued that architects were already far too much trammeled, and that, with the exception of the material parts of the construction, no general rules could be laid down. Only the useful instructions would be such as were given to the architect in each individual case. On the other hand it was urged that the intention of the proposal was not to interfere with the independence of architects. These instructions would not be for them alone but for local administrations, for ecclesiastical authorities, and for all those who are occupied, directly or indirectly, with the preservation and restoration of public monuments.

A proposal was made for the establishment of a central school of architecture at Brussels, but it was opposed upon the ground that such a measure would tend to diminish the attention paid to architecture in the academies, and to centralize the study. Other members of the commission, on the contrary, agreed with what had recently been done in France on this head, and supported the proposition as tending to strengthen architectural teaching, which in the academies was very incomplete.

Several questions set down for discussion on the programme of the commission itself were of general interest. The first was:—Whether in order to preserve archaeological traditions in all their purity, a distinction should be drawn in certain cases between ancient monuments and additions which have been made to them in later times. It was argued, in a memorandum attached to the question, that the new portions of buildings erected in past ages, were distinguished from the older parts, in consequence of the general practice of completing an edifice in the style in use at the time of such additions, without consideration of the original style of the building. This statement was contested, and instances were quoted in which the new portions of ancient buildings had been built in the style of the original epoch. The result of the discussion was to draw forth an admission that the statement appended to the question had been couched in terms too absolute, and that certainly if, in past times, architects entrusted with the restoration of a monument in one of the old styles, restored in the original style, such practice was quite exceptional; in the greater number of cases, the new constructor took no heed of the older parts.

Another question set down for consideration was:—In what case may an artist, in decorating a mediæval edifice, either by painting or sculpture, enter upon that portion of the edifice which belonged to those of the epoch to which the edifice belonged? It was asserted, on the one hand, that the figures might be dressed in the costumes which they really wore; and, on the other that the costumes should be those of the time of the erection of the edifice, no matter when the persons represented may have lived. In opposition, the commission defended the position of the case:—That there were distinctions to be made as to the course to be taken, which could not be stated in absolute terms; when the work to be done was the addition of new to ancient statues, in order to complete the sculptural decoration of an edifice, it was the duty of the artist to reproduce even the anachronisms committed by the ancient artists, but that in the case of edifices
having no sculpture, or of new buildings, the costumes adopted should be those of the time in which the personages lived.

The fourth question set down for consideration had reference to the restoration of a building should be specially remunerated for drawings of the building in its former condition, in order that the State might become possessed of such drawings, which might be engraved and published on a uniform plan. This interesting subject was, however, adjourned to next year.

The discussion of subjects touching so intimately the present art of architecture shows how lively is the archaeological sentiment in Belgium.

THE NEW GRAND OPERA HOUSE, PARIS.

The works of the new opera are proceeding sufficiently rapidly for the proposed inauguration, on New Year's Day, 1869. The sum said to be devoted to the purpose is one million sterling, of which three-fifths, if not more, have already been expended. It would perhaps be a little hazardous to say that there will not be required a certain postscript to the estimates. The employment of over twenty-five millions of francs is thus apportioned:—For iron work, two million; marble, eight million; sculpture, and other works of art, fifteen millions. Of course this is but a rough division.

The paintings in the interior are to be entrusted to M. Baudry, Bonlanger, Barrias, Delaunay, Gérôme, and Pia. It is said that the designs for these internal decorations, which have been submitted to the judgment of M. Garnier, the architect of the work, amount to several thousands in number.

The list of the statues and busts which are to decorate the exterior of the building and the vestibule is published officially. On the principal façade will be medallions of the composers, Cimarosa, Pergolesi, Bach, and Haydn. In the grand vestibule four seated statues of the four chiefs of the schools of Italy, France, Germany, and England—Lulli, Rameau, Gluck, and Handel.

In the seven salles de bateau, or small circular windows, are to be seven bronze busts, gilt; the centre will be that of Mozart, born 1756, and those of the other composers will be placed on each hand according to the dates of their birth; thus to the right of Mozart will be Beethoven, born 1770; Auber, 1772; and Rossini, 1792; and on the left Spontini, 1774; Meyerbeer, 1794; and Halévy, 1799. On the return of the façade busts of two libertists—Quinault and Scribe.

On the two lateral façades are to be placed twenty-four busts in chronological order. On one side Monteverde, Durante, Jomelli, Monsigny, Gretry, Sacchini, Lesueur, Berton, Boieldieu, Herold, Donizetti, and Verdi; on the other Cambert, Campra, Jean Jacques Rousseau, Philidor, Piccini, Pareschi, Cherubini, Méhul, Nicolo, Weber, Bellini, and Adam. In one of the foyers are to be placed busts of celebrated architects, or others connected with opera.

Among the sculptors employed are M. Carpeaux, whose fronton for the Pavillon de Flora of the Tuilleries has attracted so much well-deserved admiration.

Respecting the decoration of the interior, it is reported that M. Meissonier has made proposals for departing from his micrographic style and executing color works on the walls in the rear of the Emperor's box.

The following are the dimensions of the new opera house. The stage is in all more than 186 feet in height, the space being divided equal between the stage proper and the spaces below and above, giving 56 feet to each. The stage will be nearly 170 feet deep, and 114 deep. The principal boxes will have behind each an anti-chamber three times the size of the box itself; and the passages behind the boxes will be 20 feet wide. The immense importance of wide passages in theatres and all large public buildings, not only with respect to comfort and ventilation, but also as means of escape in case of fire, or panic of any kind, cannot be too often insisted on. No one who contemplates building a new theatre, especially for popular entertainments, should fail to visit the new Châtelet Theatre in Paris; the passages and lobbies of this beautiful theatre are large enough to drive a brougham along, and even in parts to turn it round, and the staircases are in keeping with these magnificent proportions. Another feature deserving attention is the building in front of the theatre, by which it is built with its terrace overlooking the Place du Châtelet and the Seine. The plans of the new opera-house hold out the expectation that in the matter of entrances, public and special staircases, vestibules, lobbies and corridors, the new theatre will surpass any now in existence. The Emperor's entrance has a covered arcade, so that the Imperial carriages may set down under shelter, in fact almost within the house itself.

THE BIRKENHEAD DOCKWORKS.

The Birkenhead Docks are constructed in a creek of the Mersey, formerly known as Wallasey Pool, and the first act of Parliament authorising their construction was obtained in 1844, on plans prepared by the late eminent engineer, Mr. J. M. Rendel. By an agreement made in 1856, afterwards confirmed by Parliament, the promoters surrendered the property to the Corporation of Liverpool, who subsequently vested it in the Mersey Docks and Harbour Board, and thenceforth it became incorporated with the great estate under the control and management of that body. At the time the board became possessed of the property not much progress had been made in railway communications, water frontage, and a large area of water space then opened and in use amounted to little more than about seven acres. One of the most important features of this great system is that of the large dock called the Great Float, having an area of 112 acres, a length of 1 3/4 mile, and quayage to the extent of four miles. This is sub-divided into the east and west floats by a passage 100 feet in width, crossed by an iron swing-bridge. Branching from the west float on its southern side are two basins attached to the extensive engineering establishment of Messrs. Peto, Betts, and Co., and the copper ore works belong to Messrs. Logan and Co. On the same side are two graving docks, each 760 feet in length, having accommodation and apparatus for repairing ships of the largest class; coal yards, and coal hoists worked by hydraulic machinery, and coal tips for barges are placed on the margin of the South Quay; also a powerful crane, capable of lifting 60 tons. A basin and landing slip for the discharge of timber is provided on the south side. On the southern side of the east float the establishment for the testing of chain cables and anchors forms an important feature. Two machines capable of testing up to 300 and 200 tons respectively, have been at work here since April, 1863, and additional machines specially suited for the testing of anchors, and for experimental work, are about to be supplied. The establishment occupies a large area, and possesses for the core trade being being provided with powerful hydraulic crane accommodation of the most complete description. The testing machines are worked by hydraulic power, and have been fitted up by Messrs. Sir Wm. G. Armstrong & Co., in the best manner, and with the latest and most improved appliances. Three large stacks of warehouses for general merchandise, and a spacious closed shed for the storage and goods, stand on the south quay of the east float, also the goods station of the Birkenhead and Chester Railway Company, with its extensive warehouse and shed accommodation. On the north side, a range of quay space 250 feet in width, bounded by a wide marginal road, extends the whole length of the float. The accommodation for the core trade is being divided on the north quay of the east float, in the formation of a canal dock, and by the construction of four extensive piles of warehouses six stories high. The copper ore works of Messrs. Todd, Naylor, & Co., are situated at the western extremity of the north quay, and doubtless other establishments of a similar character will follow. A line of railway is planned to connect this part of the country traverses the quays surrounding the docks.

The river frontage of these docks is nearly one mile in length, and the openings which give access to the system are of the most complete character. Of these the most important are the great northern entrances completed and opened in June last. They comprise an outer basin, with an embankment of 34 acres area, opening from the river, and leading to a lock 350 feet in length and 100 feet in width; and two lesser locks of 60 feet and 30 feet in width respectively. These entrances communicate with a dock 61/2 acres area, named "The Alfred Dock." This is con-
ON THE SCULPTURE IN WESTMINSTER ABBEY.

By Professor Westmacott, R.A.

In reviewing the sculpture in Westminster Abbey, it will be proper that the first remark should be directed to that particular place of the art, the Gothic, which is found in connection with the older style of architecture of which the building is so fine an example. Though this sacred edifice has, for many generations, been made the resting-place and the receptacle of the monuments of some of the most remarkable historical personages who have illustrated the annals of England, and thereby has claims to the attention of all who take pride in reflecting on the greatness and beauty of the English nation, it is the first interest which the intelligent visitor is chiefly and primarily drawn to those remains which can be associated with the earlier foundation. At a subsequent stage of our remarks, the sculpture of the later periods will be considered with relation to the state of art at their respective dates; but it is to the Gothic sculpture that at first the interest will be right to show how this is to be judged and estimated.

The sculpture of the true Gothic period of architecture in this country, that is, from the thirteenth century, and lasting till the middle of the sixteenth century of our era, is remarkable for a character exclusively its own. Generally speaking, it exhibits,—like all the attempts at art by inexperienced workmen,—extreme rudeness in its execution; a disregard of rules of art, in proportion and anatomy, and, for the most part, want of beauty. The earliest attempts in sculpture, only a few centuries old, cannot, however, be placed in the same interesting category with the extremely archaic monuments of Assyria, Egypt, Greece, Ethiopia, Asia Minor, and other ancient nations, dating it may be said, thousands of years since. Neither as monuments of fine art can Gothic works be allowed to take rank in illustrating the history of sculpture (proper); seeing that they throw no light whatever on the progress of imitative art, as a means of expressing ideas or sentiment by beautiful forms. Gothic architecture stretches forth its claims, in some cases, to that place in the same high position that had been attained by the great schools of the art; for, though it had fallen into neglect and disuse, it must be remembered that sculpture had been brought to the highest state of perfection sixteen or seventeen hundred years before the so-called Gothic school had any existence.

Assuming the essential conditions of fine and good sculpture to be refined expression, perfection of form, and physical beauty in all its parts, truth to nature in her boundless variety, and what is understood as style in treatment, with fine execution, it must be admitted, even by its warmest admirers, that Gothic or Mediæval sculpture must always occupy in these respects an inferior position. Any interest it possesses,—and this is very great,—must then be sought for in qualities quite distinct from those which, in the first place, to primitive works, of remote antiquity, or in the next, that is accorded to the excellence of the art exhibited; for it has, in fact, in the eye of the beholder, to be judged as an art sui generis, and not by the standard of progress and development, like other fine art, is seen in the curious fact of its maintaining, like the Egyptian and other prescriptive sculpture, its own marked and characteristic idiosyncrasy as Gothic. So truly is this the case that it is required to depart from the more modern conceptions of what this peculiarity of a school of sculpture is always more or less attempted, as a sine qua non of character, though the progress of art and the advanced knowledge of the properties which constitute excellence must make it plain to those who adopt such peculiarities that the art so exercised is not truthful as an expression of the present age, and, therefore, in this respect, it is retrogressive and unreal. This does not apply to the form of Gothic sculpture; for this, it will be seen in the course of our remarks, was much modified, according to the comparative skill or increased practice of the workmen,—varieties especially observable at Wells, Lincoln, Salisbury, Exeter, and in general in the character of the principal buildings. It referred rather, or entirely, to the manner of treatment. Here, with much that merits high praise, in its forms, it is constantly in antagonism to sound art principles, and exhibits an utter defiance of those rules of fitness and propriety which should essentially regulate an imitative art. If the human form is the object in all these cases, the same argument to show that the aim of the true artist should be to choose such conditions as will most correctly display that form, or, at any rate, that there should not be a studied effort to put into distorted and impossible action.

Portions or parts of the figure, for instance, should not be made to perform functions for which they are unitted, and of which they are incapable in nature; nor should the most perfect work of creation be represented truncated or in pieces, and so fulfilling, with the most complacent expression, ignoble and even repulsive and degrading offices. Yet, in true Gothic all this occurs, and...
is imitated as characteristic of the style. Figures represented as standing, kneeling, or sitting, are squeezed into the hollow mouldings of arched doorways, piers, or on the walls, and protrude, though in the apex of the arch the upper figures may by this arrangement be nearly if not quite horizontal. Again the most distorted attitudes are given to others, to make them fit into angles or spandrels; figures, also, in parts or entire, are made to project suddenly at right angles from the walls, to support roof-timbers, or to act as brackets, while their draperies, clinging or loose, show no natural movement, but, instead of hanging or floating, are fixed horizontally in folds parallel to the figure. In like manner, heads of angels, saints, kings, bishops, and even females are made to bear weights, as brackets under columns, or as ornamental terminating pieces on pillars, or to support doorways, for draining off the rainwater. Now, in Gothic these anomalies and the grotesques, and even indecency, that are seen in gargoyles, or draining-pipes on roofs, and in stall seats and other parts of ecclesiastical buildings, are distinctly intentional. They are not, like the crude attempts of the archaic sculptors, in consequence of entire ignorance, or of primitive rudeness of art; for they occasionally are found associated with a very advanced form of a certain kind of beauty, both of form and expression. In the heads of dripstone terminations, and occasionally in drapery, there is evidence of unquestionable power in these respects, sufficient, at any rate, to show that the strange, grotesque employment of the term in architecture was a part of the system of Gothic design, and belonged to it; herein contrasting unfavourably and to itself fatally, with the perfect sculpture which decorated architecture of the ancients—that of the Parthenon, at Athens, for instance, of which we possess the original examples.

It has been necessary to make these few preliminary observations on the peculiar feature in Gothic sculpture in order to explain much that appears anomalous in its practice. Ignorant of the true principles of sculpture, and rude and inexperienced in execution, as were the artists or carvers of the age, they yet were not so primitive, so blind, and so ignorant, as not to know that the human face was not intended to carry the weight of a column or a pillar; and, therefore, it is reasonable to assume that the fantastic uses to which the human figure was applied, formed an essential element in Gothic design. There will be enough to arrest attention in expression, pleasing forms, and, especially, in the graceful though peculiar treatment of drapery found in their works, to claim for some of the Gothic artists a large amount of our admiration; but we may not shut our eyes to the curious proofs that exhibit these, to us, contradictory and inconsistent features of their art-system; showing, beyond dispute, that they were considered as marks of the style, and proper to it. It is this which makes Gothic sculpture false and conventional, as a phase of art. Notwithstanding certain rare qualities it possessed, it is to the works and to the curiousness of our pleasing duty to direct attention, it never can be classed like the remains of the great schools of Greece, as profitable guides for them to follow.

It must be a matter of surprise, even making every allowance for the very natural prejudice against using or imitating heathen types in the employment of sculpture for Christian purposes and illustration, why, in early times, the imitative arts in connexion with our purer religion should everywhere be found so subdivided and barbarized as a state. As before observed, it was no newly invented art; and however it neglected its practice had been, still monuments and remains of ancient and superior art abounded, especially in Italy. The missionaries, priests, and monks, who first spread the doctrines of Christianity, had all come from these southern countries where such remains were to be found; on all sides; and it must ever seem strange that, when sculpture and drapery were so abundant, and the beauty and dignity appropriate to holy subjects and persons should have existed than such gaunt and uncomely productions as many of those that have reached us.

Permeability of Iron.—The master of the mint, Mr. Graham, the well-known chemist, has made a very important discovery, which he has announced in a paper read at the closing meeting of the Royal Society's session. He has discovered that iron at a very low temperature has an extremely high permeability of carbonic oxide; and that, contrary to long-standing belief, this gas does not act on the surface of the metal only, but permeates its entire substance. Having taken up the gas, the iron will retain it for any length of time, and in this condition it is best adapted for conversion into steel, as, by the permeation of the carbonic oxide, the subsequent conversion into steel is largely facilitated. Hence arises the suggestion that the process of aceration would be best accomplished by changes of temperature; a low red heat to fill the iron with carbonic oxide, after which it may be put away, if required, to await the final process, at a high temperature, of conversion into steel.
THE FESTINIOG RAILWAY.

The Festiniog Railway, or tram-road, was originally constructed under the Act 2 Will. IV., cap. 48 (23 May, 1832), and shortly after the passing of that Act. It commenced at a quarry, near Portmadoc, and ended in the interior of the principal district of slate and other quarries of the county of Merioneth, and at running for thirteen miles through a wild, hilly and beautiful country, terminated at the slate quarries of Rhitiwydaw and Duffws, in the parish of Festiniog, in the county of Merioneth. The objects of its construction were to open up a more direct, easy, cheap, and commodious communication between the interior and the outside world, and to facilitate the conveyance of coal and other heavy articles to and from the coal mines, and to the various shipping places at and within the said counties of Carnarvon and Merioneth; and to "greatly facilitate the conveyance of coal, and other heavy articles to and from the several slate and other quarries and mines in the said district, and the conveyance of the slate, copper, and other ores and products of the said slate and other quarries and mines, and of the surrounding country, to the sea side," and that it should be otherwise "a work of great public utility."

The Festiniog Railway Company, having been duly incorporated, received power to make the railway, or tram-road, and to construct the necessary works; but upon the conditions that the railway was not to pass within eighty yards of Plas-tan-y-bwch, that no stones or materials were to be raised within half a mile, or any buildings erected within one mile of Plas-tan-y-bwch, and that all steam engines employed were to consume their own smoke.

The lands or grounds to be taken or used for the purposes specified in the Act, were not to exceed four yards in width, except where it was necessary for carriages or wagons to "turn, remain, or pass each other," or for buildings or appliances to be erected, or for embankments or cuttings to be made, or for wharves, or goods stations, and work, or building to be above sixty yards in breadth at any place, except on commons or waste lands, or by consent of owners.

The Company was not to occupy more than was absolutely necessary of the Tract Mawr embankment near Portmadoc; the gauge between the rails was not to exceed three feet upon that embankment, and the superstructure of the embankment was not to be disturbed more than one foot in depth, and the ordinary traffic upon it was not to be interrupted.

The estimated cost of the line was £24,185 10s. and the Company was authorized to raise £10,000 by loan. Powers were afterwards granted to raise further sums of £2,000 by shares, and £4,000, at the total Parliamentary capital of the Company is £50,185 10s.

The population of the district, in 1832, was very limited, and the line was therefore laid out in an economical manner, and on a gauge of only two feet between the rails. But from time to time, as the traffic increased, many of the curves have been eased, dismantled, and made larger, at great expense for the purpose of obtaining better gradients, and avoiding steep inclines; and improvements have been effected in the permanent way, though without any alteration of the gauge. The difference in level between the terminus at Portmadoc, and the mountain terminus at Dinas is 700 feet, and the average gradient for 12½ miles, from that mountain terminus, to the Tract Mawr embankment near Portmadoc, is 1 in 92. The steepest gradient on the portion now used for passengers is 1 in 78½, and the steepest on which locomotive engines are employed is 1 in 60. Some of the curves are exceedingly sharp, having radii varying respectively from 3 chains to 4 chains. The maximum super-elevation allowed for on the line is on a curve of 2 chains, is 2½ inches, for a speed of 8 miles per hour.

As the slate quarries are at different altitudes in the mountains, the slate cars are first brought down the quarry inclines to the railway, and the trains are then collected and forwarded in trains to Portmadoc. These trains, sometimes composed of fifty trucks or ten, are run down by the force of gravity, and are in charge of breaksmen.

Until 1863, the empty trucks, or trucks loaded with coals, goods, furniture, materials, machinery, and tools for the quarries and the neighbourhood, were drawn up by horses, which were brought down in the trains, as on some of the colliery or mineral lines in the North of England.

As the traffic increased, and after the railway had been much improved, the practicability of employing locomotive engines on so narrow a gauge was frequently discussed, but the project was more than once abandoned, in consequence of the apparent difficulties, and of the adverse opinions expressed by the Engineers who were consulted. At length the continued increase of the slate traffic, and of the trade of the neighbourhood, caused it to be revived; and Mr. England was employed, under Mr. C. E. Spooner, the Secretary and Engineer of the Company, to design and build an engine for the line. The engines were accordingly placed upon the line in June, 1863, and were found to work so successfully that others have since been supplied. The Company now possesses four engines, which have run, (up to February, 1866), 57,000 miles without leaving the rails.

During the past autumn the Company carried passengers experimentally, without taking fares, and at the commencement of the present year, the line was regularly opened for passenger traffic. In ascending from Portmadoc, the passenger-carriages are drawn by the engines with other vehicles, the passenger-carriages being placed between the empty slate-trucks, which are always last in the trains, and the goods-waggons, which are next behind the tender. In descending, the loaded slate-trucks, with empty goods-trucks attached behind them, run first in a train by themselves; the engine follows, tender first; and the passenger-vehicles, detached from the engine and tender, and at some little distance behind them, bring up the rear, with a break van in front, and a lamp platform outside the last wagon. The speed of the trains, six miles per hour, in passing round the sharpest curves, and ten miles per hour on other parts of the line. The passenger-guard, standing outside his van, is always ready to slacken speed, by the application of his break, in approaching level crossings and sharp curves, or in obedience to a signal, or in the event of an accident on the line; and the crews of all the engines of the trains, are able to follow each other, at the above moderate speeds, more closely than could be done, with safety, on ordinary railroads.

The engines, though on a much smaller scale, are of a somewhat similar plan to those used in some of the smaller English and Scotch railways. The wheels are 4 in number, and are coupled together, 6 feet apart, and are 2 feet in diameter. The cylinders, which are placed outside the frame, are 8 inches in diameter, with a length of stroke of 12 inches, and are only 6 inches above the rails. The maximum working pressure of the steam is 200 lbs. to the inch. Water is included in the boilers, and coal in small four-wheeled tenders. The heaviest of these engines weighs 7½ tons in working order, and the cost was £900 each. The average load taken upon the line of 8 miles per hour on the ascending journey, is 50 tons, including the weights of the carriages and trucks, but exclusive of the empty slate-trucks. The engine and tender together, with the equipment of the engines, exclusive of considerable shunting, is to convey daily, on the up journey to Portmadoc, along the Tract Mawr embankment, average loads of 260 tons of slate, all the empty slate-trucks from Portmadoc, 50 tons of goods, and 100 passengers, besides parcels, at an expenditure of 17 cwt. of coal and coke for two engines, or about 0.75 ton per mile, or 0.8 tons per mile at an average ascending gradient of 12½ miles being 1 in 92, and there being a level portion for about three quarters of a mile near Portmadoc.

The high pressure at which these engines are worked, combined with the small driving wheels, gives them a surprising amount of power for their weight. Two locomotive engines, one for the incline, and one for the down, are required for convenience in starting and for working at slow speeds. The centre of gravity also has been kept as low as possible, with a view to steadiness on so narrow a gauge. But their short wheel-base, and the weight which overhangs the trailing wheels, imparts more or less of a jumping motion in running, which might be avoided by the addition of trailing wheels, working on a circle in radial axle-boxes, to steady them. Efficient safety-guards, similar in form to snow-ploughs, have been added in front of the engines, behind the tenders, and under the platforms of the break vans.

The passenger-carriages are necessarily of a different construction from those in ordinary use on railways, and are also low. Their dimensions are 6 feet 6 inches high in the middle above the rails, 10 feet long, and 6 feet 3 inches wide, outside measurement. Each carriage has 4 wheels, 1 foot 6 inches in diameter and 4 feet apart, from centre to centre of the axles. There is a longitudinal partition down the centre, and the passengers sit back to back, so as to avoid causing an overhanging weight outside the rails. The second and third-class carriages, cost £100 each, and do not differ from the first-class carriages, which
cost £120 each, except in their fittings. The springs are volute, and the axle-boxes, which are under the seats, are easily lubricated on the removal of a small door opposite to them. Each carriage will convey 10 passengers. No platforms are required, as the doors of the carriages are only 9 inches above the rails; and, there being no break in the longitudinal partitions, the passengers pass through out through sidings, to the above carriages; but without sides and roof. The passengers are strapped into these carriages by means of longitudinal and cross straps.

It is a question whether longer carriages on 8 wheels and bogie frames might not be used for sharp curves on other lines of unusually narrow gauge with advantage. But it is considered, that carriages of greater length than 18 feet would be inconvenient for moving about at the stations. If the curves on the line had not had any radii of less than 5 chains, there would be 13 feet, with 6 feet 6 inches centres for the axles, would have been adopted. The couplings are central, similar to the screw couplings in common use, are 15 inches above the rails, and work on volute springs. The buffers are also central, are 44 inches above the couplings, and work against a curved spring, 5 feet long. The Author believes the Canadian, British and others, which are on the Continent, of a single link, with a double spring connected with each draw-bar, would probably be found well suited to act at the same time as buffer and coupling, at slow speeds, on railways of this description.

The permanent way is now laid with rails weighing 30lbs., to the 100 feet, and distributed with lengths of 12 feet 6 inches. The rails are supported in cast iron chairs, which weigh 13 lbs. at the joints, and 10lbs. each in the intermediate spaces. The sleepers are of larch, 4 feet 6 inches long, and averaging 10 inches by 5 inches in section under the joints of the rails, and 9 inches by 4 1/2 inches elsewhere. They are placed 1 foot 6 inches apart, on 9 inches centres, and the rails, 2 feet 8 inches apart in the intermediate spaces. The rails are secured in the chairs by wooden keys, and the chairs are fixed to the sleepers by wrought-iron spikes, 4 1/2 inches long by 1 inch diameter.

There are 12 bridges under, and 5 (foot) bridges over the railway, as well as numerous stone viaducts across the valleys. Most of the smaller openings are covered by girders, or rather slabs, of slate. There are also two tunnels, one 60 yards long, and the other 730 yards long; the former through hard shale, and the latter through syenite rock, which is sufficiently solid to require no lining.

The Author, of course, had many difficulties to contend with in transforming a horse-tramway, thirty-three years old, into a passenger line worked by steam locomotives; and not the least of these difficulties has arisen from the narrowness of the works. The stone walls, with which the greater part of the line is fenced, as well as the abutments of the bridges and the tunnels on this line, would be desirable to provide, on any lines of an extra-narrow gauge which may be constructed in future. The carriages, being 6 feet 6 inches wide, overhang the rails by about 2 feet on each side; and this renders it desirable that the tracks at the sides of the line should be at least 4 feet 6 inches from the rails, and that a total minimum space of 9 feet 6 inches should be preserved between the sides of the carriages and the tracks; and the width of the structures would therefore depend, not so much upon the gauge of the rails, as upon the dimensions of the carriages employed upon them.

In like manner, where the line is doubled, or where sidings occur, it is necessary that an intermediate space of 7 feet should be preserved between the tracks, in order to clear the axles of the vehicles of another train, and for other reasons; their dimensions also varying according to different widths of gauge and carriages.

The Author concedes that the employment of locomotive engines on this line, and the working of it for passenger traffic, are not only highly interesting experiments, but are likely also to be followed by important results. There can be no doubt, that this country owes her abounding prosperity of recent years mainly to the rapid development of railway communication, and that the increase of that prosperity in future years will depend much upon the facilities for, or, in other words, upon the cheapness and rapidity of transport which may be provided for passengers and produce, between all parts of the kingdom, by these facilities. These facilities are partly derived, partly from improved carrying powers on some of the existing railways, and partly from the construction of new railways. Every new line in an agricultural, a manufacturing, or a mineral district, tends to stimulate production, to provide means of employment for an increasing population, to add to the supply of food, and to bring into full use the resources of the country, which are now dormant.

There are still, doubtless, many districts where railways on a gauge of 4 feet 8½ inches may be profitably made; and, indeed, the number of miles of such railways annually projected and carried out has, of late, been increasing rather than diminishing. Although only 477 miles were opened for traffic during the past year (1864), over 600 miles were projected for the present session, against 3,099 miles for the session of 1864. But there are also many other districts in which lines of cheaper construction are required. Railways on the gauge of 4 feet 8½ inches can hardly be made more economically than at present, as far as regards the permanent way, or the Author believes that the Chessel, the Balsam, the railway that require heavy engines, and heavy engines require substantial bridges and a strong permanent way. On the other hand, with a narrower gauge, lighter rails and sleepers, less ballast, and cheaper works generally may be employed; sharper curves may be laid down; very heavy gradients may, particularly in mountainous country, be got over; and lighter engines, with lighter vehicles, may be made to do all the work required, where high speed is not demanded, and where the traffic is not heavy.

The Norwegian government, as appears from an interesting report by Mr. C. D. Fox, has constructed, and has in full operation, two lines, one from Gundersett to 4 feet 2½ inches gauge, 24 miles long, and the other from Thonheim to Storen, 30 miles long, both on a gauge of 3 feet 6 inches. The former, with gradients of 1 in 70, and curves of 1,000 feet radius, through a moderately easy country, has cost, including rolling stock and stations, £30,000 per mile. The latter, through a more difficult country, with gradients of 1 in 42 and curves of 700 feet to 1,000 feet radius, has cost £40,000 per mile. The rails weigh 37 lbs. to the lineal yard, and are fixed at the joints. The sleepers are of native pine timber, 2 feet 6 inches apart, 6 feet 6 inches long, and 9 inches by 4½ inches in section, and the rails are secured to them by dog spikes only. The engines weigh 14 tons, in steels, 1,600 lbs. to the cubic foot, 24 feet 6 inches wide. The speed is about 15 miles per hour, including stops.

The Norwegian government is so pleased with the result, that an additional length of 66 miles of this gauge is now in course of construction, and no other gauge is contemplated for the traffic of that country.

It is, however, illegal at present to construct any passenger lines in Great Britain on a narrower gauge than 4 feet 8½ inches, or in Ireland than 5 feet 3 inches. The Act 9 & 10 Vict. cap. 87, provides (sect. 1), "that after the passing of this Act it shall not be lawful (except as hereinafter excepted [with reference to broad gauge railways]) to construct any railway for the conveyance of passengers, the one from Gundersett to 4 feet 2½ inches gauge in Great Britain and 3 feet 6 inches in Ireland," and (sect. 6), "that if any railways used for the conveyance of passengers shall be constructed or altered contrary to the provisions of this Act, the Company authorized to construct the railway, or in the case of any demise or lease of such railway, the Company for the time being having the control of the works of such railway, shall forfeit ten pounds for every mile of such railway which shall be so unlawfully constructed, or altered, during every day that the same shall continue so unlawfully constructed or altered; and sect. 7 gives power to the Commissioners of Woods, &c., or to the Board of Trade, to abate, or remove such railways not constructed, or altered, contrary to the provisions of the Act. It would therefore appear to be necessary, before constructing any railways for passengers on a less gauge than 4 feet 8½ inches, or before attempting to open for passenger traffic any railways so constructed subsequently to the year 1840 (in which the above Act was passed), to endeavour to obtain, if not its repeal, at least a modification of its provisions. That Act was passed after the Report of the Gauge Commissioners, when
there was a strong feeling against break of gauge, and when there was no immediate prospect of a third and a narrower gauge being extensively required. But there is now an increasing demand for branch railways of a minor class. Many coal and mineral lines are to use on a narrower gauge than 4 feet 8½ inches, and others are now being constructed on 3 feet 6 inches or 4 feet 3 inches, and the traffic. It would therefore be an advantage if some smaller gauge were recognized; for however objectionable the existence of different gauges on important through lines of communication may be, it is quite otherwise with respect to the use of a narrow gauge for feeding branches, in districts where a similar gauge to that of the main line would not be commercially practicable. Passengers change carriages, under any system, at the junctions of less important branches; and it is considerably cheaper to transfer heavy goods from one railway truck to another, than to cart them for several miles, perhaps over indifferent roads. The Festiniog Railway, on which the original gauge has necessarily been maintained, in consequence not only of the works, but also of those of the tramways and quarry inclines running into it, is an extreme example, outdone only by the little engine which does the work of the shops at Crewe on a gauge of 18 inches; and the cost of that railway, under the peculiar circumstances of its original construction and subsequent alterations, cannot be taken as a guide for the future. A gauge somewhat wider than 2 feet 2 inches would probably be desirable on any line to be now constructed, and it would hardly be worth while to desert the gauge of 4 feet 8½ inches in Great Britain for any wider than 2 feet 6 inches. But whatever the exact gauge, 3 feet or 4 feet 6 inches, or 3 feet, or any other dimension that might be considered for lines of minor traffic, there can be no question, that a system of branch lines, costing two-thirds of the branches now ordinarily constructed, and worked and maintained at three-fourths of the expense of those branches, would be of decided benefit to Great Britain and Ireland, and would be most valuable in India and in the colonies; in fact wherever there is a sufficient train of goods to be transported, or resources to be developed, where would not be commercially profitable to incur the expense, in the first instance, of a first-class railway.

Captain Tyler said, having been called upon officially to inspect this railway, he thought a brief description of it might be interesting, and he hoped that description would be the means of calling forth a discussion of great use, in elucidating the important question, whether it was desirable to have a narrower gauge in this country, under peculiar circumstances of locality, and having regard to the nature of the traffic. There were already in Wales, a number of different gauges used on tramways for bringing slates and minerals down to the ports of shipment; and in other parts of the country. A red-rhine gauge had been adopted on the Manchester, Bury, and Hyde Extension Railway, after it had been found, 100 miles were in course of construction on the gauge of 3 feet 6 inches, and 200 miles more were projected on the same gauge. It was important to ascertain, what would be a suitable gauge for such a case. As regards the Llangollen, it would be difficult to say; but it would be a narrower gauge. Farmers were now using portable railways, for transporting the produce of their fields, for bringing in their harvests, spreading manure, &c., and there seemed no reason why districts, which could not support a railway on the gauge of 4 feet 8½ inches, should be altogether deprived of the advantages of railway communication. The question of gauge was, in one sense, a question of speed. Speaking roughly, on a railway of 2-feet gauge, with 2-feet driving wheels, travelling might be made as safe at 20 miles per hour on as the Great Western, with its 7-feet 2-inch and 7-feet driving wheels, at 70 miles per hour. He had travelled on parts of this little line at the rate of 30 miles per hour with every feeling of safety. He regretted the unavoidable absence of Mr. Spooner, because it prevented him from thanking that gentleman, in the presence of the meeting, for the informing speech that had been delivered in opposition of the gauge, and because, if he had been present, he would have been able to give further information on the subject. Mr. Spooner took great interest in this line, and was accustomed to travel on it along the Truth Mawr estate, and had found it to be perfectly safe, and was well acquainted with the gauge."
ment would adhere, in all cases, to the resolution requiring the gauge of 6 feet 6 inches. On the other hand, the objection to a uniform gauge for both main line and tributary branch was, as alleged by the managers of the companies, that they had no proper control over their servants; and that if a man was accustomed to drive an engine of 30 tons on the main line, he could, if he chose, run the same engine on to the lighter road, very much to its injury; whereas, having a different gauge effectually prevented crossing over between branches. In a case argued on the establishment for the repair of the engines, that all the locomotives should be the property of the parent company; the engines could then go to the same shops to be repaired, which would be a convenient and economical arrangement. Mr. Thordendal referred to the Irish and Scottish 3 feet 6 inches gauge, which he had referred to, had been obliged to send out all the tools necessary for the repair of the engines of 3 feet 6 inches gauge, whereas if the gauge of 6 feet 6 inches had been adopted, arrangements might have been made for the whole of the rolling stock to be repaired by the passenger and luggage companies under an agreement with the engineer. He thought it was more important to limit the weight on the driving wheels than to fix any particular gauge, the latter being a matter which must be determined by the circumstances of each case. After a good deal of consideration on the subject, he thought if he had now to establish a gauge to be used all over the world, he should fix it at 6 feet 4 inches. The Irish gauge of 6 feet 3 inches was a very good gauge. The Indian gauge of 6 feet 6 inches was also a good gauge, but it necessitated a rather heavy rolling stock; while the gauge of 4 feet 8½ inches was, in his opinion too narrow. At the same time, unless there was some strong reason for departing from the universal gauge of any country, he would follow out that gauge in even the light tributary lines.

With respect to Queensland, the government of that colony had decided on a gauge of 5 feet 3 inches, and the plans were referred to him for confirmation: more than 100 miles were now being constructed, and authority had been obtained for 200 miles more, the "material" of which was now being prepared. In the Queensland gauge, 5 feet 3 inches gauge, all the "material" and rolling stock had been sent out from England, the sleepers being of teak. The line was laid upon an old road, which was granted to the Company by the Government, and which required some alterations in the works and in the stations. The total cost, including rolling stock, would not be quite £3,500 a mile. With regard to the radiating axle boxes referred to in the Paper, and which had been adopted for sharp curves on the Norwegian lines, he was informed that they caused much injury to the lines and to Queensland. He believed, that on the Queensland railway, 5 chains was the sharpest curve, and that 1 in 40 was the steepest inclination; that the weight of the rails was 40lbs. to the yard, and that the engines with which they did not exceed 16 tons to the beam, were ready for work, exclusive of their tenders, carrying fuel and water.

The most important reason for using the narrow gauge, in this instance, was the construction of circular lines through mountain ranges, where it was impossible, except at a great expense, to get a gauge of 4 feet 8½ inches of long radius. If it had not been for the sharp curves, he would not have recommended the narrow gauge for the Queensland lines; and it must be borne in mind that being the first railways in that colony, there was no existing gauge for the sharp gauge of these lines had to be adopted. He hoped, however, that the line would be carried up to Atkinson; and not lead to the supposition that he would lay down a railway, with a gauge of 6 feet 6 inches, to a slate quarry in Wales; his observations applied only to such lines as were tributary to main systems of railways.

Mr. Stephenson declared, that all the Norwegian lines alluded to, were isolated. The original line made by Mr. Stephenson and Mr. Bidder, had been extended to the confines of Sweden, and was entirely constructed on the gauge of 4 feet 8½ inches, with which the other lines of the country were likely to be brought into communication. Radiating axle boxes, he understood, had been recently introduced on the Norwegian lines with considerable success: the weight of rails generally adopted was 37lbs. to the yard, laid in lengths of 21 feet, the gauge 6 feet 6 inches, 3½ inches high, with a base of 3 inches, laid on cross sleepers, and flax-jointing. In some cases a plate had been used, which, from the experience obtained in England, was not considered a desirable arrangement. Upon the subject of narrow gauge Norwegian railways, he had, however, received a communication from Mr. Pihl, who, in 1856, was entrusted by the Norwegian Government with the task of supplying railway communication between Thordendal (about 350 miles northward of Christiania) and Stornor, the point from which two main carriage roads ran south; and between Hamar, on the Lake of Hamar, and Christiana (about 250 miles of Christiania) was in direct communication by rail and steamer, proceeding eastward to Eleverum, upon which the traffic of the Glommen Valley converged. Mr. Pihl stated, that he determined, from the difficulties of the country and the cost of the works, to use the narrow gauge; and he recommended a narrow gauge of 3 feet 6 inches. This was adopted by the Government, and was constructed by the Ingerslue (Storring) in 1857, and shortly afterwards the works of both lines were proceeded with.

The works upon the Hamar line, being the more easy of construction, were sufficiently advanced to be used for goods traffic in the summer of 1858. The total cost of this line, for 24½ English miles, had amounted to about £2,000 per English mile. This included a large iron bridge, about 900 feet long, for ordinary railway work only; the cost of the rolling stock of 3 locomotives, 6 passenger carriages, 3 break vans, and 50 goods wagons, with the necessary ballast wagons and tools for repairs; also two terminal stations, and six intermediate stations and the necessary buildings and bridges. Although the works were not of a heavy character, there were nevertheless many difficulties to contend with, the line having to ascend upwards of 400 feet, and to cross extensive and deep swamps.

The Hamborh line, running through a difficult country, required many heavy works of construction, among which were numerous large bridges, some being from 70 feet to 100 feet high, several cuttings containing from 50,000 cubic yards to 70,000 cubic yards of earth, and more through rock of more than 30 feet in depth. The total cost of this line was near £7,000 per English mile, including 4 engines, 8 passenger carriages, 3 break vans, 60 goods and plank wagons, besides 20 ballast trucks, with the necessary implements for the repairs. There were besides the terminal stations, six engine, engine, and station houses and the cost of formation of from 11 tons to 12 tons, out of the 14 tons to 16 tons, the total weight. The last engines procured were provided with bogeys, on Bissell's or Aadam's system. The cylinders were 10 inches in diameter, with a length of stroke of 18 inches, and the wheels ran on 3½ feet in diameter. All the engines were made in England, with the exception of one made at Thordendal, and were working efficiently. The passenger carriages were constructed to carry the usual number of passengers, as in England, and were arranged for triple construction only, the inner forming 16 ft., the outer 10 ft., and the carriage 18 ft. (in consequence, the centre of gravity. The buffers were all central, and 2 feet 6 inches above the rail level, and served also as draw-bars. The collars on those last constructed were self-acting when the wagons were brought together. As this narrow gauge allowed a correspondingly larger wheel base than the ordinary gauge, the wagons ran very steadily. Some of the wagons were constructed to carry planks 24 feet long, and had a length of wheel base of 13 feet.

The usual rate of speed was about 15 miles per hour, including stoppages, and the trains ran quite as steadily on this line as on the broader gauges. The traffic on these lines, though considerably below that of the lowest of the English lines, had already paid the working expenses, with the high development of the resources of the country must undoubtedly, in course of time, produce a corresponding and satisfactory increase of revenue.

In order to show the economy of construction, Mr. Pihl mentioned the simultaneous with the construction of these lines, an extension of about 50 English miles was made, with a very small cost. The line was built by Messrs. Stephenson and Bidder in 1850-53 to the Swedish frontier, of the ordinary gauge of 4 feet 8½ inches, the cost of which was about £2,500 per English mile, the rate of wages and the class of work being, as near as possible, of the same description.

In addition to the narrow gauge lines described, there was in course of construction, another line of the same gauge, between the town of Drammer and the Lake Randsafjord, about 85 English miles in length, being a general branch line on a high level, the formation of these several lines would ever have been made, had not the small cost justified and encouraged the undertakings.

(To be concluded in our next.)
GEOLOGY AS APPLIED TO ARCHITECTURE.*

BY JOHN CUMMING, P.G.S.

(Continued from page 211.)

To CRUSH AWAY is the very nature of stone; indeed, every formation has been used by mankind for the making of building bed of rock, either by wind or rain, mechanically or chemically, or by both, or by the beating of seas or rivers on the surface. We cannot expect, then, that the same materials, hewn and placed in a building, will more successfully withstand similar influences. All, however, are not open to the same amount of destruction, and a knowledge of the phenomena attending the Sandstones is met with, as we have already seen, in almost every stratum, but very few of them are of any value for constructional purposes. Sandstone in every case consists of larger or smaller particles of silica or flint, held together either by mere aggregation, by calcareous cement, or by oxide or carbonate of iron, and sometimes by silicious cement; the last-named are always the best and most indestructible. The most homogeneous samples should be selected, and those free from iron. Sandstones, however, do not generally commend themselves for enduring qualities; but occasionally examples have been employed that have stood the test of centuries and remained uninjured; and the time of the Houses of Parliament were about to be erected, a committee was appointed to decide upon the most useful and lasting stone to build them with, and the prominent buildings of this country were examined as to their state of preservation and the length of time which had elapsed since their erection. Of the 11th century, Chepstow Castle, partly built of red sandstone, is decomposed, and in Durham and the same, Fountains Abbey and Kirkstall Abbey, both much decomposed; and the only 11th century work mentioned as being built of sandstone, which is still sound, is Richmond Castle, even the mouldings and carvings of which are said to be in a perfect state. The examination was conducted through the buildings of the 13th, 14th, 15th, and 16th centuries, and the result was not sufficiently satisfactory to induce the committee to recommend sandstone for its durability.

The sandstones used at the present time are better than those formerly employed. The Craigleith sandstone, from the carboniferous formation in the vicinity of Edinburgh, is the most satisfactory, as it contains 98 per cent. of siliceous rock, and only about 1 per cent of carbonate of lime. The sandstones from the Millstone Grit of Yorkshire are good, and where used have lasted for centuries. A very hard and lasting stone (if well selected and used in dry places) is the freestone from the Greensand rocks. In the neighbourhood of Goodrich and Nutfield many buildings are constructed of it, and appear to last well. The same quarry, however, often yields various qualities of stone. Patterson Court, Nutfield, the residence of Mr. Norman Wilkinson, is built of this stone from a quarry on the property. The older portion of the house is in perfect condition: the more recent, although built of stone from the same quarry, is flaking off and crumbling away rapidly. The sandstones from the Wealden formation, notwithstanding some of them appear very hard, soon crumble to pieces, and should on no account be used for any building intended to last. This stone has little or no cementing material in it, unless (as in some cases) carbonate of iron, which would be better absent. Sandstone may sometimes be employed in situations where moisture is the rule, when in exposed places it would be liable to destruction by the atmosphere. In selecting sandstone for building, and, indeed, any stone, it is well to observe in any adjacent quarry how the undisturbed strata have been treated by exposure to the weather. Experience must of course decide, for many sandstones that are soft in the quarry (when newly cut) become hard and very good afterwards. Limestones for building purposes may be classified as Portland and Bath ooliths, magnesian limestone from the Permian formation, and the various carbonates of lime. For ornament, Portland stands the best stone for colour, durability, and ease of working, but not for cast. Even this stone must be carefully selected. Many beds of stone are found in Portland, not all of which yield the material which has made the island famous. The best stone is denominated the White bed, and the terms Cup, Kerf, Roach, are applied to the remainder. The Roach beds consist of open stone, containing the casts of numberless shells, and is used with success in structural parts, but they require the greatest care. In many cases where Portland stone has failed in London, the material has been obtained from the western side of the island. These instances should warn the architect to state specifically the bed of stone he wishes to employ and the quarry from whence it is to be obtained. St. Paul's Cathedral, Greenwich Hospital, St. Bartholomew's Hospital, the west tower of Westminster Abbey, are all built of Portland oolite and are in good condition. The magnesian limestone has commended itself to architects for its fine colour, ease of working, and tolerable endurance. There is no building stone, however, that differs so much in quality as the magnesian limestone. This is well illustrated by the Houses of Parliament. In 1839 a Commission was formed to inquire what was the best and most enduring stone to employ for their erection. The geology, the chemistry, the mechanical science, the experience of the country, were well represented. Hundreds of buildings, whose dates extended from the 10th to the present century, were examined. These buildings were of sandstone and limestone, and careful and mature deliberation, magnesian limestone was selected, upon the strength of the fact that Southwell Church, Nottingham (built in the 10th century of that stone from Bolsover and Mansfield), Bolsover Castle, 1629, and other edifices, had stood the test of centuries, and were perfect still. The opinion of the Commission is given in the following words—

We feel bound to state that, for durability and durability, the magnesian limestone, of Bolsover Moor, is the best fit to be employed in the proposed Houses of Parliament.

And these gentlemen arrived at the above conclusion after well considering about 80 or 40 varieties of building stones, and examining hundreds of buildings in which they were used. Stone from the quarries of Anston was afterwards found useful when large blocks were needed, at the suggestion of the late Mr. C. H. Smith. The Masons of Bredastone made the offer of an abundance of granite from the neighbourhood of Oban, and it would seem almost a pity it was not accepted.

Twenty-two years have elapsed since the selection of stone from Bolsover Moor and its neighbourhood; and then it became necessary to inquire into the cause of the decay of the stone of the Houses of Parliament. The evidence showed that Southwell Minster, upon the perfect state of which so much reliance had been placed, was not built of Bolsover stone, but of Mansfield stone. Large quantities of stone were used from Anston because large blocks were more easily obtained. Care was not taken to select particular beds; the stone in the quarry was sometimes chosen by the quarryman because it was easier to work; and sufficient importance was not given to the employment of the best stone in positions where damp and rain-drip were sure to exercise their baneful influence, in combination with the chemical disintegrators of a London atmosphere.

Most of the evil might have been obviated if a competent person had been employed to examine every block of stone sent from the quarries. Such a man was Mr. C. H. Smith, and £150 a year was offered to him for the work,—a paltry sum, indeed; but he was willing to undertake the work. When ready to commence he inquired who was to pay him, and as the architect said the Government would, and the Government said the architect would, Mr. Smith declined to undertake the work, and did nothing further in the matter. No one was appointed, and of course the office of inspector was neglected.

Anston stone has stood well in the Geological Museum, Jersey Street, but very badly in the Hall in Lincoln's Inn, both built at the same time, from the same quarry. The stone used by Mr. Giswel for the roof of the House of Commons, unheeded deliberately selected the softest stone; hence the decay. In the former, Sir H. de la Beche selected the stone himself. You will perhaps say the failure of the geologists, chemists, &c., to select durable stone, militates against my theory of the usefulness of such knowledge as they possess. It is true the mistakes of the past are many and instructive; and no more instructive comment on the question we are discussing can possibly be obtained than the Blue Books of 1839 and 1861, containing all that is known or can be said upon the subject. The committee of 1861 elicited the following statement from three chemists, Hoffman, Franklin, and Abel,
who were appointed to examine into the reason of the decay of building stones, and it is so interesting that I think I shall be pardoned if I give it entire.

Regarded from a purely chemical point of view, the difference in the resisting power to corrosive agents of different stones, would appear at first sight to depend entirely upon their chemical composition; but even a moderate acquaintance with the properties of the components of such building stones demonstrates that chemical determination is equally instrumental in determining the degree of permanence of different stones.

It is a well-established fact, that the same chemical substance exhibits, in building stones, a great variety of effects, according to the mode of contact with the agents of destruction. Numerous examples might be quoted in illustration of this. Thus, marble and chalk are chemically identical, but, owing to the difference in their physical structure, the one being crystalline and the other amorphous, the former is much more readily acted upon by acids than the latter. Peroxide of iron, in the form of hematite, is attacked with difficulty by acids; and the same oxide, after exposure to a powerful heat, is almost entirely insoluble in acids. The influence of aggregation in these instances, and in numerous others which might be quoted, is obvious and generally admitted by chemists, however different and imperfect may be their views regarding the connexion between physical condition and chemical effect.

It will be just made regarding the behaviour of substances, such as enter into the composition of building-stones, cannot but apply with equal force to the aggregates of such components—to the building-stones themselves.

The more arbitrary influences to which building-stones subject are many of them essentially chemical actions, involving processes analogous to or identical with those performed in the laboratory, although, from the extreme dilution of the chemical agents, as existing in the atmosphere, there will be no question of instantaneous action. It is obvious and generally admitted by chemists, however different and imperfect may be their views regarding the connexion between physical condition and chemical effect.

There are few instances in which the influence of the state of aggregation to which the permanence of a building-stone is more apparent than in that of the dolomite limestone, used in the construction of the new Houses of Parliament. How the small and the large parts of stone are subject to decay; it is therefore legitimate to attribute the unequal preservation of the stone, under atmospheric influences, to such structural differences as may be comprehended under the term—state of aggregation.

In proceeding to an examination of the particular character of the decay observed in the stones of the New Houses of Parliament, it may possibly be desirable to glance at the nature of the changes to which building-stones generally are subject under atmospheric influences. Unfortunately, the changes to which these substances are exposed are, for the most part, those which are not susceptible of chemical investigation. For instance, the action of the oxygen, carbonic acid, nitric acid and water in the atmosphere. In the air of towns, however, there are certain other constituents, such as several acids of sulphur, and occasionally hydrochloric acid, which considerably accelerate the rate of decay. There exists, therefore, an additive diagenetic influence upon building-stones.

The action of oxygen must be of comparatively a subordinate character, its effects being confined to constituents which occur but rarely, and which are subject to a quick destruction, such as the sulphides of iron, and the protoids of iron and manganese; these compounds, being very prone to oxidation, would tend to disintegrate the stones by the absorption of oxygen. Of greater importance are the effects of carbonic acid and water. Carbonic acid, in the presence of water, is a powerful solvent; it not only corrodes the calcareous and magnesian carbonates (more or less powerfully according to their state of aggregation), whether they form the principal constituents of the stones, or are only present as cementing materials, but is capable even of attaching and gradually decomposing the hardest and most indestructible rocks.

In the case of the calcareous and magnesian constituents of stones, causing by the partial dissolving of the insoluble earthy carbonates into soluble bi-carbonates, which are thus removed from the substance of the stone, whilst its influence on siliceous rocks consists in the elimination of the alkaline bases, in the form of carbonates, and the separation of the siliceous in a more or less friable condition. The weathering of granite, and their gradual transformation into the several varieties of slate, olivary, and the like, affords an interesting illustration of the latter kind of action. In the changes just mentioned, the carbonic acid and water are equally efficacious; the water serving not only as a vehicle for the introduction of the carbonic acid into the stone, but also as the agent for the products of its action. There are, however, to which building-stones subject, in which water is the sole agent, and which are more of a mechanical than of a chemical character. The effect of the water, upon freezing, is the most conspicuous; the pores of a stone must exercise a disintegrating action not less powerful than those above referred to.

Recent researches have demonstrated that nitric acid is a frequent and perhaps even a normal constituent of the atmosphere, and, as such, must undoubtedly assist in the destruction of magnesian and calcareous stones; but the proportions in which this acid has been found, are so minute, that it can hardly be considered as of little importance. This remark, however, does not apply to the acids referred to above, as existing in the atmosphere of towns. The quantity of sulphur-acids in the air of towns, where a considerable amount of coal is consumed, is not inconsiderable. According to determinations of Dr. Gregory Smith, the air of Manchester contains an average proportion, corresponding to one part of sulphuric acid in every 100,000 parts of air, which, in the centre of the town, rises to 25 parts in 100,000. No numerical data are available regarding the relative influence upon stones, and the apparent absence of nitric acid in the atmosphere of the New Houses of Parliament, they are present to an extent equal to the average amount found in the Manchester air; they must, therefore, be regarded as among the more important agents destructive to stone, and may contribute to a great extent to the rapid decay of the material in the House of Commons.

A few observations remain to be offered regarding the particular nature of the decay manifesting itself in some of the stone of the New Houses of Parliament. It has already been pointed out, that so far as our experiments prove, the principle of action in this case is not due to the presence of solutions of carbonic acid, as we have pointed out, the earthy carbonates (in which respect it resembles carbonic acid in its effects) but, forming with magnesia a readily crystallizable salt, the well-known sulphate of magnesia, which forms, as a secondary deposit, on the surface of the stone, when exposed to air and water, and which increases in amount and intensity, as the stone becomes more and more porous.

The mechanical processes resulting from the solidification of water, introduced by decaying agents, which, in the case of winter, although of slow action, they have been previously considered as auxiliaries in the process of disintegration of stone. The analogy between the solidification of water, by freezing and by crystallization, is perfectly obvious, and a French chemist has suggested, as a means of recognising stones liable to freezing and crystallization, to note out the sulphate of magnesia, and to note the subsequent effects of its crystallization within the stone.

We have ourselves recently had occasion to observe some phenomena which go far to elucidate these destructive effects of crystallization.

Numerous processes have been patented, and some have been tried, for clothing stone buildings with a silicious coating, so as to exclude the action of moisture, the chemical action of the atmosphere, and the mechanical action of frost; but none, I believe, have quite equalled the expectations of their inventors. I will not enter into the merits of any of these processes, as they do not strictly belong to my subject.

The action of frost upon stone may be illustrated by the method employed by the quarrymen of the North. Instead of using the powder for blasting (a certain quantity of which is served out to them) in anticipation of a frost they cut channels in the stone to be detached, and fill them with water in the evening, and generate frost in the stone in the act of congelation effects the purpose.

A point, the importance of which is too often ignored and neglected in the employment of stone for building, is that of placing each stone upon its natural bed. All rocks have been deposited either grain by grain or layer by layer. It
is quite certain, then, that force applied to them will act more readily on the plane of stratification than upon the transverse section. If stones of no great adhesion in their particles be built into an edifice on end, it is equally clear that from well suit an edifice of the thickness of the wall to partake of its action. As there are numerous examples in Oxford of the carelessness shown in this particular, and by the small-poxed aspect of several buildings we are warned to use as much circumspection as possible in this respect, to prevent similar results in the present case.

To obtain complete knowledge of the available building stones of the British Isles is easy. At the Museum of Practical Geology in Jermyn-street, there are cubes of nearly all the stones that have been used in building the principal edifices in the kingdom in past and present times. Those who wish to see how the varieties of stone may be employed for architectural purposes should visit the Oxford Museum. Professor Phillips thus describes the stones of which the building is composed; he says—

Though the stone of which the Museum is built, and the marbles which are employed in the internal decorations, can hardly be regarded as a part of the collection of rocks, they must be included among the objects to which the student of geology should devote some attention; and were indeed in part selected for the purpose of adding to the illustrations of the sciences.

Some variety of colour in the front of the building was desired by the architect; and in the interior one hundred and twenty-seven polished shafts, which the structure required, gave opportunity for exhibiting a specimen of the different varieties of English, Welsh, Scottish, Irish and Jersey limestones. The limestones, and the marbles, and the statuary marbles, are employed. Slabs of Portland stone have been placed in the spandrels for carving.

The court, which is in the lower colonnade, and in the walls of the arches, which contain red sandstone from Bristol, and a somewhat softer stone, of paler tint, from Coventry. The court is paved with yellow and red sandstone from Mansfield, and grey stone from the Forest of Dean. By the arches and pillars in the corridors we can see the different varieties of English, Welsh, Scottish, Irish and Jersey limestones. The limestones of the arches, and the capitals of those in the lower corridor, are of Caen stone. The sculpture of the capitals and corbels is intended to represent examples of the principal natural orders of plants: the ornamental carving on the gates is taken from British plants.

Geology and architecture have here united to produce much to admire artistically, and more, if possible, to educate to a just appreciation of the combined power of art and science.

A knowledge of geology will be found useful to the architect when called upon to suggest places in which to sink wells. The site of buildings in the country often depends upon the ease with which a supply of water can be obtained. Numberless are the cases in which the architect was misled by the apparent convenience and outlay. What is the meaning of a spring? It is rain water that has found its way into the permeable strata of the earth, and by some impediment, as a fault in the stratification, a thinning out of the water-bearing seam, or the basin-like form of some of the deposits has been potted up, as it were, and whenever a fissure or crevice, either naturally or artificially produced is made, the water bursts forth. Wells are of several kinds, all depending, however, upon the relative position of the strata from whence they proceed. Thus, if we have an inclined stratum of impervious clay, over which there is a deposit of sandstone or porous limestone, and then again a bed of clay, nature has provided a main that has only to be tapped more readily than a supply, commensurate with its size and the level at which it is tapped. If again this main in one spot or other has slipped down, producing what is technically called a fault, that is to say, when the porous bed is stopped by the juxtaposition of one of the strata which we require to tap. The rationale of their will rise through any aperture in the superincumbent mass till it acquires the level of the highest unobstructed part of the water-bearing seam.

Artesian wells, so called from Artois in France, where at one time great success attended the method of procuring a water supply, are also made of similar strata. But their action is more simple. Let us take London and the neighbourhood. In a depression in the chalk of a basin-like form are deposited alternating beds of sand, gravel, and clay. Water falling on the upturned edges of the more porous of these fills them, but the water cannot escape to reach its own level, for the clay above retains it. In the Artesian well this stratum of clay is tapped, and by a small opening, the water eagerly rises till it finds the surface; and the whole supply in the stratum of clay is tapped till the water is at the surface. Sometimes when a large supply of water is required the boring is continued through all the tertiary beds till the chalk is reached, and here, from the enormous area of chalk exposed to the rain fall, a permanent yield of water may be relied on.

One well at Letiers, in France, sunk in 1826, has yielded the same quantity of water uninterruptedly. In 1839, at Greenoble, a well was sunk to supply Paris with water, and at 1800 feet from the surface a supply was reached yielding nearly one million gallons per diem, the first rush of water rising 120 feet above the surface.

The Artesian wells in London and its vicinity are numerous, and they range from 200 to 500 feet in depth. To attempt (as has been done) to make these borings without a knowledge of the geology of the district will nearly always result in disappointment and lamentable failure.

Some beds having a free egress at their lowest extremities, instead of yielding water, act as mere drains, and sometimes carry off what can ill be spared. A case occurred some few years since which will illustrate this. A gentleman, encouraged by the success of a neighbour, sunk a well in his garden, and obtained but a moderate supply of water, and this not permanent. He had reached a stratum of stiff clay on which rested a thin bed of sand. Determined to seek a larger spring he sent well after well to the bottom of the dry clay. You may conceive his dismay, when, at one hundred feet, he discovered that he had lost his first spring and had gained a second. Why? Because he had virtually made a hole in the bottom of his well and drained it into a stratum of sand that for all the water it could get. The operation of draining wet lands has often been facilitated by the application of this fact in geology, and thereby the cost of conveyance through pipes to a distance has been saved.

On the importance of geology, in ascertaining the positions in which water will most likely be met with in the strata of the earth, General Portlock remarks: If we were in a country in which we desired to know whether it would be possible to find water, our geological knowledge of stratification would enable us to predict that after penetrating a certain portion of porous strata, we should find a bed of clay retaining water, and hence that, by artesian boring we should procure it; but, if on the other hand, we knew that there was nothing but a great mass of sandstone, we should not expect that the artesian or other stratum capable of holding up the water we should know that it would be useless under such circumstances to seek for it. In like manner, we should not look for water in granitic rocks. I recollect an instance myself at Fort Henry, in Upper Canada, where there was a great desire to sink a well in the limestone; but each bed of stone was laid on the other by the river's current, and all have heard, the turning stick and the knowing man, having held his stick in his hand of course it turned round, and the place to which it pointed it was assumed water would be found. The authorities were so deeply impressed with the accuracy and certainty of this mode of discovering the presence of water, that orders were given to sink the well. This was in a solid mass of granite. The difficulties were great and the expense enormous; but who could doubt the infallibility of the stick? Hence, not certainly wisely, though energetically, the attempt was persevered in till it became absolutely necessary to stop, an instance which will show you how important it is to have some little knowledge of the principles of the science.

Serious evils have arisen for the want of careful geological investigation in the proper disposal of cesspits and cesspools. Should a well and a cesspool each be sunk in the same stratum, and the cesspool occupy the higher part of that stratum, it can easily be seen that the cesspool will most suffer. By your account, it appears the cesspool is at a disadvantage not so deep as the well. Such precautions avail nothing very often, for the thin water-bearing beds sometimes occupy various levels even in a small area. I know that such pits and pools are supposed to be made water-tight, but are they always so? Do they always keep their water in? You gentlemen speak of the percolation, the predisposing causes of which are bad water and bad air. In making cuttings, digging wells, or in any other operation affecting water-bearing beds, it is necessary to see that in looking to your own interests you do not damage
those of your neighbour. Many litigations and serious losses have arisen from a want of the knowledge of geology in such cases. One example will sufficiently illustrate this. "In 1843, the Leeds and Thirsk Railway Company projected a tunnel through the Bramhope Hills, from which the springs and streams that partly supply the Eccup Reservoir, before a tunnel was there to Leeds. The company, by employing the aid of geologists, was saved from a severe loss, whilst both the contractor for the tunnel and the railway company, by ignoring that aid, incurred heavy expenses."

A knowledge of geology will enable the architect to determine if the soil on which he intends to build will give a good foundation. Captain Hutton, from whom I have just quoted, speaks of the case of Fort Elson, at Portsmouth, as follows: — "During the construction of Fort Elson, at Portsmouth, part of the escarp wall subsided, and slipped forwards, the clay being squeezed up in front of it, as is shown in the diagram. This was owing to its having been built upon the London clay. This shows the importance of this clay, its great tendency to slip and be squeezed out when any weight is put upon it, is well known to geologists, and I may add, to railway directors and engineers, the cuttings in it being always a source of trouble and expense. When the South Eastern Railway was first made the slips in the cuttings through this formation were so great as occasionally to stop up the line; and even now the vibration produced by the passage of trains often causes slides to take place, or loosens portions in such a way that the next shower brings them down. If then the weight alone of the fort, and that even before it was finished, was sufficient to make the foundations give way, what might we expect to have happened, had a column of the enemy's guns?" Precautions have now been taken against these accidents; but, if the knowledge of geologists on the subject had been used, the expense of pulling down the sunken portion of the wall and repairing it would have been saved.

In finding limestone wherewith to make cement, sand for mortar, stones for road making, &c., geology will be found to render material assistance. When the inland fortifications were being constructed for the defence of Portsmouth, cement was wanted for the construction of the new forts. This cement was made from nodules of calcareous clay called septaria, which come originally out of the London clay; but at Hotham, from which the principal supply is obtained, they have been washed out of the clay and are dredged up in large quantities from the sea. Now the forts at Portsmouth are built on the same London clay in which these septaria are found; but, in ignorance of their nature, they were actually broken up and used in the roadmaking. When the road was brought by rail to Torry Foot, near Aberdeen, a case was given me by the Rev. James Cumrie, author of "The Geology of Bramar," relative to the necessity of geological inquiry where building materials are wanted. In the erection of the fortress of Torry Foot, near Aberdeen, instead of taking gravel from the neighbourhood, sand was taken from the sea-shore, quite fresh; but it was then mixed with salt. The consequence was that, when frost set in or the guns were fired, it trickled down from between the blocks of granite like the sand in an hour-glass.

Road materials especially call for the knowledge of the science we are discussing, to ascertain the fitness or the reverse of the materials for the purpose. Geology having determined the stratum upon which the road is to be carried, the material wherewith to metal it must be sought. Tough stones are preferable to hard ones, flint is hard and easily broken, some limestone is tough but soft, chert which is a kind of flint, is both tough and hard. Granite and many of the early rocks make excellent roads, but their selection requires great care. Syenite is often the very best metalling a road can have, but is not always easy to procure. Geologists have to determine the construction of the road in the Crimea from Balaklava to the front, were whatever happened to be nearest. These from the harbour to the top of the plateau were olitic limestones and sandstones, and all the rest of the way soft tertiary rocks. Now the whole of these, with the exception of a hard crystalline limestone, are very inferior materials for roads, and when there is much heavy traffic, as was the case in the Crimea, are sure to be soon ground down into mud. But the beach outside the harbour of Balaklava is composed of compact greenstone, the very best road-making material known; so much so, that large quantities of it are brought from the Channel Islands for the streets of London; and if a geological survey of the country had been made this must have been found, and a good military road would in all probability have been with it. The instance I have quoted shews the value of a made knowledge of geology to the engineer. I might, were it necessary, multiply cases in which geology, if pressed into the service of the architect, would simply repay him the time spent on its study.

I hope that the little insight I have given you of this science in its application to architecture may beget a desire to dive deeper into and learn more of a study that cannot fail to interest all who pursue it. A little knowledge of geology will not be found a dangerous, but a very useful thing to the modern architect.

THE TELEGRAPHIC SYSTEM.

On the first day in the present year, great reductions were made in the telegraphic tariff between various states of the continent, and the Journal des Débats has seized the occasion to show how wide-spread the system has become, and what means of communication now exist in Europe and between that and other parts of the world. It appears that on the 1st of January there existed nearly seven thousand telegraphic offices in Europe. Two lines connected Europe and Africa, one going from Marsala, in Sicily, to Biskra, in Tunisia, and being in connection through the lines in the latter country with Algeria; the other line extends from Malta to Bengazi, in Tripoli, and is then continued to Alexandria, in Egypt, by a cable which runs along the coast. This second line was intended to make part of the great one to India, but the difficulty of preserving a cable on the coral reefs of the Arabian gulf made it necessary to seek another course; its use is therefore limited to communication between Europe and Egypt. The last named country is also connected with Europe, as well as with Asia, by a line which traverses Syria, touching at Jerusalem, Alexpo, Tripoli, Beyrount, crossing the Bospaurus, and joining the lines of Turkey, in Europe.

Dispatches for India may be sent by two routes. The first is by means of the Italian lines, the cable which connects Otranto and Valona, and the lines of Turkey, in Europe and Asia, and reaching to Bassora on the Persian Gulf; it then runs in the same manner as cable submerged along the coast as of that gulf and of the gulf of Oman, and is connected with Indian lines at Kurraheen. The second route is by way of Russia, the Caucasus, and Persia, to Bassora. The Indian telegraphs possess one hundred and sixty-one stations, and the island of Ceylon four.

Dispatches for China are now sent by way of Russia, and are transmitted through the lines of Russia proper and Siberia to the Tartar frontier town of Kiachta. From this point they are carried by the Chinese post to Pekin, a journey which occupies fifteen days.

America is not yet brought into telegraphic relations with Europe, but Russia and America are conjoined at work in establishing a line by way of Siberia and Behring's Straits. The third attempt to lay the great transatlantic cable, as is well known, is now occupying the attention of the whole world; and another line, long projected, that of M. Baletrini, is expected to be carried out shortly, through the co-operation of several continental states with the United States Government, or an American company.
INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

PRESIDENT’S ADDRESS.

(Concluded from page 193.)

Among the vast works recently executed or being proceeded with at home, the main drainage of London and the Thames embankment stand prominently forward; the former beyond all precedent the noblest, and so far most successful work of municipal sewering ever produced; for antiquarian rubbish as to the closures of ancient Rome seems to rest on no foundation of reality, but from personal examination I can state my own opinion, to be that the so-called Cloaca maxima was never intended for a sewer at all.

The water of the Thames already begins to sparkle under even its partial defacement. There is good ground for wishing that the outfalls, however, were removed farther down the river, and the Essex sewage project of Messrs. Bateman and Hemans, if carried out, will be attended with that advantageously result as respects the greater portion of the discharge from the northern sewers.

Like projects are mooted for the south side of the Thames, and it may be said that in all probability the final completion, under the able conduct of Mr. Bateman, of the whole main drainage system, will not tardily result in vast improvements and extensions of the methods of distributing sewage as manure over large tracts of arable and pasture land, to be ultimately followed by the general defacement of our rivers and streams all over the country, and the utilization of the manure now poisoning them as water-sources.

The Thames embankment, which now shows itself above water in several places, is remarkable, not by magnitude alone, but by the rapidity which has been conferred upon its execution, by the most extensive and complete system of contractor’s steam plant ever before applied upon any purpose. Scores of small and mobile engines have been dubbed to the leading, dredging, pumping, mortar and concrete mixing, and numerous other purposes, have here reduced the work of years, if done by manual labour, to that of a few months.

The employment of wrought-iron caissons for sinking to, or for obtaining foundations, have here, as well as at several of our new bridges on the Thames, and more particularly in the two bridges at Blackfriars, under the direction of Mr. Joseph Cubitt, proved of the most inestimable service as methods of construction in water.

In strata analogous to the London clay, where beds of stones or boulders are unknown, the probability is that the experience of the last two years will be largely relied upon by the old form of coffer-dam for pier foundations, but where pervious, unequal, and stony strata are encountered, the double row of timber or of iron piling will no doubt continue in use.

Besides the Westminster new bridge, the work of Mr. Page, and beyond question, as measured by capaciousness and convenience, both for water passage and for traffic, the finest of existing London bridges, the Thames has but recently been spanned by the Charing Cross and the New Cannon Street railway bridges, both of iron, and both founded on cylindrical hollow pile piers, and also by the fine railway bridge by Mr. Bekar at Putney, and a new structure leading to the Victoria station in London, has spread itself across Battersea. In the construction of these bridges it has accepted the Lambeth Bridge, conspicuous by its ugliness, though said to be, like a plain but well dowered bridge, in a financial point of view a success; and another, on the peculiar stiffened construction of Mr. Ordish, has been projected at Battersea.

The rivers of the Continent have within a few years past been crossed by many bridges for railway or for road traffic, embracing some of the noblest structures of the sort in the world. Among these may be specially noticed the railway bridge lattice bridge of Dreschau, on the Vistula, which connects the Russian and Prussian systems of railways, in six spans, each of which is composed of a chain of lattice girders, and in the construction of which the great economy residing in the lattice, as contrasted with the tubular or box girder system, has been strikingly shown. The bridge of Mainz, upon the Rhine, is a fine example of construction in tension trusting upon the great scale.

Upon the same great river we may not pass without notice the fine bridge at Kehl and Strasbourg, the last great work of Emile Vugner, whose death last year every engineer deplores. Nor can we omit the noble railway iron bridge at Bordeaux, the design of which, though on a much larger scale, resembles that of the Charing Cross bridge over the Thames, and of that at Poitou at Londonderry, which has been carried out by Mr. Hawkes, in near perfect accordance with the designs furnished anteriorly by myself to the Londonderry bridge commissioners.

Among the works or projects at home of the hour that in virtue of their magnitude or novelty claim a word of notice, may be mentioned the iron viaduct by Mr. Brunlees, now erecting over the historical Scots’ Bridge, for giving improved communication between the English and Scottish railway systems of more than a mile and quarter long, an exposed structure, the main lateral stability of which is given by its covering platform of buckled plates.

In project only as yet, but likely to become accomplished works, we have the gigantic railway viaducts intended to cross the Frith of Forth, and that proposed by Mr. Fowler across the Severn below Gloucester.

Steam ferries, to carry railway trains unbroken across the English Channel, and so to unite the English and Continental systems, have found projectors sanguine enough to propose them, and no doubt the result of the capabilities of the future. It time, belongs Mr. Bateman’s bold project for the supply of London with two hundred million gallons of water per day, to be abstracted from another and a distant river basin, viz., from the upper reaches of the river Severn.

Second to none of these in ultimate importance to mankind, and in the immediate interest which it justly excites, is the Atlantic telegraph, now gathering its strength asears, after a second defeat, for what we hope may prove a final conquest over natural difficulties. Let us observe, however, that the misfortunes of the Atlantic cable cannot in any strictness be attritted to bad ship, to bad materials, but to misfortune in the ship’s company; and that whenever a perfectly insulated cable shall be made, that without any hitches or hauling up by the way shall have been once paid out, its being laid safely, and as a result the establishment of telegraphic communication between the old and new worlds, is a matter of almost perfect certainty. Improvements daily taking place in the hands of electrical engineers as to the methods of transmitting signals and accelerating these greatly, give a reasonable expectation that when completed this undertaking will prove remunerative.

Human power over both cold and heat in their applications to the progress of society is already but lastly not unimportant acquisitions. The ice-producing or freezing process of M. Carré by ammonia, of Harrison and Siebel by ether, and of Kirk by expanded air, have already found important applications in chemical and other manufactures, and perhaps ere long as refrigerators for the brewer; while the methods of heating by gas burnt with only its exact equivalent of air, brought prominently and practically into use in the arts by the classical researches and labours of Kelvin, have received fresh interest from those of Deville, who has shown that the most refractory metals can be fused by the heat of gas furnaces; and based on this, and on the freedom of gas flame from the impurities evolved from the charcoal, and on the inferiority of iron in particular of the highest importance—not second, indeed, to the improvements made by the application of machinery to the puddling process, which has recently become in France and in South Wales an accomplished end.

While thus referring to the progress of foreign technology, a word may be given to improvements in relation to public health effected in public baths and lavatories, and in the heating and ventilation of public buildings in France: the latter are largely indebted to the labours of Morin, whose able work on the subject appeared at Paris the year before last. Nor should we wholly pass the new processes of sugar manufacture and the improvements, by treatment with the acid phosphate of lime, which seems likely to prove of great importance.

Having thus dwelt upon the progress and improvements making in other lands, I will now refer to our engineering progress in this country.
Our past president, Mr. Mullins, has given us an admirable résumé of the later history of civil engineering in this country, extending over about two centuries. It embraces nearly all that the practical engineer need perhaps care for. I cannot but wish, however, that some one yet would give us the much earlier history of engineering in Ireland, which blends in that of the domestic, ecclesiastical, and military architecture. For notwithstanding what we owe to Petrie (whose recent loss we still regret), to Wilkinson, and others, we remain in want of one to tell us, with the same loving zeal and earnestness that Viollet le Duc has given the history of the military architecture of France between the eleventh and thirteenth centuries and onwards, how, for example, the perfect and yetJointed ashlar of the tower of Clonmacnoise, the quaint cloisters of Muckross, and the walls of Jerpoint; who delicately chiselled, six centuries ago, the limestone mullions of Howth Abbey; by whom the groning of Clare, Galway, and the Spanish doorways of the old City of the Tribes were drawn; who designed and constructed the deftly walls and castles of Limerick, Tredagh, and Carrickfergus; whose taste decided the flow of the palatial buildings at Kilmallock; who planned the many residential fortificates of Elizabeth’s reign; or later still, who designed and fixed the details of Stratford’s palace at Naas, with its Dutch brick and coloured tiles and its brickwork, open now, is truly splendid, the deliberate modem master’s eye.

These would be noble memories, gentlemen, to call up, though even these cannot be without occasional bitterness and regrets, for much even of the architectural history of this country is stained with violence and bloodshed; and when these must be referred to it had better be with the outspoken truth with which Parnell has lately told one of its saddest stories. But while the historian or the archaeologist has occasion to refer to old antagonisms, and does it truthfully, for the heartburnings they have left to our own day can never be repressed or removed by falsification or palliation of wrong on any side, let us all now, in a practical and thinking men, say them, "The past is past," and turn our attention to the present and the future. For it is now time, I think, to consider the present and look forward to new enterprises, for if our own profession, which is one with progress itself, or if any art or trade is to root and prosper in this land, it can be alone upon the basis of genuine tranquillity, and the abandonment by every class of every chimera.

The social circumstances of Ireland are exceptional, and peculiarly unfavourable, in some respects, for the development of engineering or industrial works. No great staple manufacture has rooted in the soil, with the exception of that of linen in the north. With few large cities or towns (which have been in the history of all countries the centres from which arts and industries have spread, and which in this case are heavily fixed with “seits” imported from Wexford, while better material, from which skilled labour might have fashioned them, is abundant within forty miles of Dublin.

The law of progress in every country is from pasturage to agriculture, thence to commerce, and ultimately to manufactures. Yet Ireland is no exception--the one stage above nomadic life, advocated; and such is the prevalent want of knowledge of the conditions of manufacturing success or failure, that when a fitful gleam of prosperity induces some little stir, projects as chimerical and baseless as a plate glass manufacture, a beet-root sugar or a beet parsnip company, find subscribers and supporters. When the remembrance of events confounded, serve long to dampen or prevent every well-placed and considered enterprise.

For there are many sorts of manufacture, many industries of arts, that may be attempted in Ireland, bearing in view its actualities, both natural and social, with rational grounds and good hope of success. I must not detain you with particulars, but I may say in illustration that to give the best hope of commercial success, industrial enterprise here should seek to bring forth the rude riches that nature has placed below the surface of Ireland, and subject these to such primary transformations as may make them in the first place articles of export, and perhaps of manufacture; and that no industry which is either wholly exterior or refined in character, or which demands a large supply of the higher order of skilled labour is likely to prove permanently successful.

An improved systematization of the railway traffic of this country and reduction of rates, as advocated by so much concurrent and independent testimony before the parliamentary committee and so many on railway matters, put upon comprehensive principles, would not only permit and awaken many such enterprises, but it is indispensable preliminary to their success. Nothing also could better tend to develop the completion of the network of the Irish railway system, necessary to bring all parts of the island into contact with the points of import and export, which are so much confined to the northern, eastern, and part of the southern coasts. In the existing state of Ireland and of the railway interests belonging to it, it may be said with certainty that the system of county guarantees is nugatory as promoting public works in railways.

In an early in this address, alluded to the bad policy with which (as appears) all the railway and transport and even direction of public works was about fifteen years since abandoned in this country. In one special department this abandonment seemed suicidal, and it appears to me that the time has finally come when the government in this country might wisely and with great advantage re-evince and re-establish the principle and the plan of an act of the executive, moved to it by the clamour of Irish landowners, who some of them no doubt found themselves in a position of financial difficulty through the pressure of the times, from which this course presented in far the readiest but the most sighted exit. Not only were works in progress brought to a halt by abortive conclusions, and mature projects abandoned, but no sufficient provision was made for the effective future maintenance of those completed.

Now here is a class of works that no laissez faire policy, even though it were applied to the richest country in Europe, can ever be carried out in a country here covered by millions of acres still of wet and sterile bog, with a climate exaggeratedly declared to be so moist as to be only fit for pasturage, and from which the culture of wheat (the very type amongst crops of social advancement) is impossible; and yet these great drainage works were showing distinct meteorological signs of ameliorating this condition of climate at the very time they were suddenly abandoned.

Everything seems to point out that at the present time, after due consideration and amendment of the Arterial Drainage Act so as to adapt to those changes which circumstances and the lapse of years have produced, those works might with the greatest advantage, public and private, be now resumed.

I have detained you long in thus looking back upon the shadowy side of the landscape. We, however, who are familiar with the country know that it here and there is not devoid of sunshine also. Though there are no public or private works of engineering recently begun and completed to which we can refer, there are yet some which have been growing year by year in importance, to which we may advert with satisfaction. Among these some of our harbour works stand prominent.

The port of Dublin affords a fine example of the success that can attend a single well-devised work in harbour engineering; for although the steam-dredging operations so long carried on by the Ballast Corporation have considerably deepened the channel of the river Liffey itself, it is chiefly by the direction given to the tidal scour by the Clontarf wall, suggested by Chapman and carried out by Giles and the elder Halpin, that
the increased depth of water upon the bar has been produced. The steam dredging operations upon the river have been conducted with improved appliances by the existing engineer of the corporation, our fellow-member, Mr. B. B. Stoney, who has had constructed iron hopper barges for removing by steam tonnage the dredged material to suitable places of deposit of the unprecedentedly large size of 1,000 tons burlen.

Belfast harbours is another favourable example of harbour engineering under circumstances of considerable difficulty and complexity, an excellent account of which has up to a rather late date been given here by my predecessor, Mr. M. Mullins, V.P. At the present time vessels drawing 22 feet of water can come up to the town at high water of ordinary springs, so that the docks increased has been practically to more than double the available harbour depth, and to give the town a fine chain of docks and basins, with a wharfage of nearly 8,000 feet, and at a very small outlay under the circumstances.

I am indebted for an excellent history of the various projects and works for the improvement of Belfast harbour to my friend Mr. George Smith, C.E., now consulting engineer to the port, and who for twenty-seven years held the responsible position, of its acting engineer:—

The harbour of Belfast was originally in the creek or river that runs down the centre of High Street, and empties itself into the river Lagan. It is now covered over as a sewer.

The first Belfast Harbour was on the north side of the charter of James I., where the inhabitants are allowed to embody a guild of freemen, and to erect a wharf or quay. An impetus was given to the trade in 1837 by the purchase, on the part of the Crown, of the exclusive privileges enjoyed by Carrickfergus to one-third of the duties on goods imported into that town, and other monopolies. For a century after the trade was confined to this small river. In 1720 a quay, from the mouth of the creek to the Long Bridge (now the Queen's Bridge) was built, and now forms part of Donegal Quay, extending from the Queen's Bridge to the foot of High Street. This was the commencement of the present harbour.

As the trade of the port increased the dues upon shipping became of importance to the Government, and they appear to have given considerable attention to the subject, and early in the present century they obtained reports from the most eminent engineers of that day, with the view of procuring greater security for the shipping and the revenue of the port.

At the commencement of the present century the Government would not only grant the merchants temporary assistance, by way of loan, they found themselves thrown on their own resources; and from the time that Mr. Rennie reported to the commencement of the works of improvement in 1838, the harbour committee had designs for docks from the most celebrated engineers of the day, as well as from others of no note. The result is a dock with an extremity of more than 5 feet of water, which could not get up to the town at low water, but on its completion there were from 10 to 11 feet, and from the upper end of the channel downwards towards Garmoye there is now not less than 13 feet at low water, and at high water spring tides 22 feet.

In examining the plan of Belfast harbour, it will be seen that beyond the entrance to the channel the ground falls steeply, and towards the Seal Channel, where it begins to deepen, and continues to do so as far as the buoys of the middle Bank, where there is 19 feet at low water; it then gradually shallows till it reaches the lighthouse, where the pool ceases, and the lough becomes of the general level. Various reasons for this formation have been given, as very little alteration, if any, has taken place in it for many years, the most favourable one being that the bottom of it is filled with springs from the land. In examining the Seal Channel in opposition to some of the railway bills, I found that wherever the Seal Channel sent out forks, or minor channels, there it immediately deepened the same as Garmoye, which commences to deepen at the junction of the Seal Channel with the middle Bank of the Channel. Do not these pools arise from the current of the two streams forming eddies at their junction, which the soft slough of the lough is not able to withstand, and gulls itself into a hole or pool? I mention this, as there may be some novelty in the idea, but it is a very feasible one, for the ground is so soft, as I have previously stated, that it will not stand even more than 5 to 1. It is causing great annoyance to our present works.

Simultaneously with the making of the Victoria Channel the river opposite the town was very much widened, as well as straightened, from the bridge downward to the upper end of the channel. The Queen's Quay was put 250 feet farther into the county of Down than that on the opposite side Donegal Quay was removed 60 feet into the river, so as to gain width for sheds between it and the street.

I am sorry that I cannot give you any information respecting the increase in the velocity of the tide after the making of the channel. I did not take any observations till after it was opened.
when at half ebb it ran from \( \frac{1}{4} \) to 1 mile per hour during neaps, and in freshes 1\( \frac{1}{2} \) to 1\( \frac{1}{2} \) miles per hour. I do not think the alteration made much difference, as the tide had free scope up to the town when I took my observations; but as the banks of the river are being gradually closed in by our improvements, I expect it to be a making place.

Since the formation of the Victoria Channel upwards of 7900 feet of quays have been made or renewed, and a patent slip erected capable of taking up vessels of 1000 tons. We have works in progress that will cost £150,000, the principal being a graving dock, 460 feet long and 16 feet water on the sill at high waters; also a floating dock, 1400 feet long and 500 feet wide, capable of taking in vessels drawing 23 feet at neap tides.

A third harbour to the improvements of which we may point with pleasure is that of Londonderry, at present probably the most rising town and port in Ireland.

I have been favoured by my friend Mr. Thos. Stevenson, of Edinburgh, one of the engineers engaged in these improvements with the following brief account of the works, to the complete success of which I can speak from personal knowledge, having been myself intrusted by the port and harbour commissioners with the valuations of the whole of the ancient quays, frontages, and warehouses, in a petty extension of a high and necessary preparatory to their being swept away, to make room for the new quay, alongside which ships drawing more than 20 feet can lie up:

So recently as 1854 the quays of Londonderry were owned by private individuals, each proprietor occupying a portion of the quay in front of his warehouse, and building his own quay in any direction and of any material, according to his own fancy. Each portion of quay was walled in, and there was no thoroughfare along the harbour in front of the warehouses. A more inconvenient arrangement could hardly be conceived. In 1854, however, an Act of Parliament was obtained incorporating the commissioners of the port and harbour of Londonderry, and empowering them to levy dues and borrow money for the purchase of the private quays and the construction of works on a large scale for the improvement of the port. These works were designed and carried out by Messrs. David and Thos. Stevenson, of Edinburgh. The whole of the private quays have been purchased and removed; spacious quays affording a roadway of 90 to 80 feet in width, have been formed along the harbour for a distance of 3730 feet, at a cost, including dredging vessels and the purchase of property, &c. (which amounted to about £64,000) of about £130,000. A new graving dock has also been constructed. It is 314 feet in length, and has a depth of 6 feet 9 inches at the foot of the tide, of 4 feet 9 inches at the low water of the ebb, and with pumping engine and other necessary appliances has cost about £24,000. The works of the quays were chiefly contracted for by Mr. M'Cormick, M.P., and Mr. M. McClelland and those for the dock by Mr. Hugh Kinloch, of Leith. The whole was carried through by Mr. M'Donald, as resident engineer under Messrs. Stevenson. The only other portion of the parliamentary work remaining to be executed is the dredging of the “flats” in the lower part of the estuary, which it is intended to deepen to the extent of 3 feet for the distance of nearly a mile, so as to afford a depth of 22 feet at high water. These dredging operations in Lough Foyle have been as yet only partially carried out. In addition to the several lighthouses which have been either built or remodelled. The Royal Mail Montreal Steam Ship Company's first-class American steamers now make Londonderry their port of “call” and “departure” for landing and embarking mails and passengers; and the ancient city of Derry, with its rapidly-increasing trade and its connection with the whole northern part of Ireland, bids fair to be soon one of the most flourishing ports in that country.

The works were commenced in 1855, since which time the tonnage of the port has nearly doubled itself, and, as stated by the secretary in his letter of 2nd October, 1865, “it is the general opinion of the masters that the immense accommodation has nowhere been supplied at a lesser cost, and every portion of the works still maintains as high character for stability and effectiveness as when completed.”

The Vartry waterworks for the supply of this city, though a needlessly expensive project, will no doubt when completed afford a public supply. Some account was recently given by Mr. Neville to the meeting of the mechanical engineers in this city, which was probably listened to by the majority of our own members.

I will briefly advert to one topic more, though a little out of its proper place, inasmuch as it is one that presents the fairest opportunity of establishing in this country a new branch of manufacture and a genuine course of remunerative return, under conditions which Ireland presents peculiarly well-developed.

Henri Sainte Claire Deville, the illustrious French chemist, in the course of certain recent researches, has discovered that some compounds of hydrate of lime and hydrate of magnesia afford a cement of eminently hydraulic properties, and setting rapidly under water. He has further found that the natural dolomites, which consist of carbonate of lime and carbonate of magnesia, in proportions either of one atom of each, or of two or three atoms of the lime carbonate to one of magnesia, if calcined at a very low red heat and ground to powder, produce without any other treatment a fast setting hydraulic cement, which becomes so hard that it may be employed also as an artificial stone, which for architectural purposes retains the fine warm tint of colour of the dolomite in its natural state. Now in many parts of Ireland dolomite is abundant as a quarry rock. It can be obtained at a fine creamy white colour, and very free from iron and manganese, which would in the preparation darken its colour as a cement.

The amount of heat required for its calcination is very slight, and may with great advantage and cheapness be communicated in furnaces heated by gas evolved by the imperfect combustion of peat, employing a modification of Charles Siemens’s regenerative furnace. The calcined stone can be ground by water power, and the casks for packing the cement may be a subsidiary manufacture, and even made from small native timber, but little skilled labour is required. The materials are all at hand; the product directly marketable. The process which has been given to the world by Deville is hampered with no patent. Here seem to be the conditions for at least one new industry in Ireland. Let us hope that the hint may not fall wholly unproductive.

In conclusion, if I have extended this address at an unreasonable length, I have had a wide scope of subjects to deal with; and while none are without points of contact to engineers, on some that have been touched upon we must, whether as connected by different ties to this country or as British subjects, feel deeply interested for they bear upon the welfare of us all.

INCURUSTATION IN MARINE BOILERS.

By P. JENKEN.

(Carried from page 200.)

This plan of admitting foreign substances into the boiler to neutralise the salts, or some of them, contained in the sea water, has found favour with a great many inventors; suffice it to say that nothing has appeared in the light of the eye of late years more promising than soda. Mr. J. B. Napiers has gone into an estimate of the commercial advantage of using soda ash for incrustations. He assumes the boiler to work at 270 deg. per square inch, and evaporating at that temperature 7½ lb. of water from 100 deg. per lb. of coal. The following is his table. —

<table>
<thead>
<tr>
<th>Mechanical method.</th>
<th>Chemical method.</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Sea water supplied to boiler at 100 deg.</td>
<td>15 lb.</td>
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<tr>
<td>these were discharaged at 370 deg.</td>
<td>26 lb.</td>
</tr>
<tr>
<td>Water evaporated</td>
<td>7 lb.</td>
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<tr>
<td>Total heat evaporating from 100 deg. at 370 deg.</td>
<td>99 lb.</td>
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<tr>
<td>100 deg., &amp;c.</td>
<td>31. Ty. 91.</td>
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<tr>
<td>Fuel discharged</td>
<td>1,074 lb.</td>
</tr>
<tr>
<td>Fuel consumed in evaporation</td>
<td>1 lb.</td>
</tr>
<tr>
<td>Fuel consumed in preventing crust</td>
<td>165 lb. coal</td>
</tr>
<tr>
<td>Total fuel</td>
<td>1,145 lb. coal</td>
</tr>
</tbody>
</table>

Thus it seems, he says, that it requires only 172 lb. of coal + 65 lb. of soda ash, containing 60 deg. of soda, to be as efficient in preventing crust as 100 deg. of coal alone, which evaporates 7½ lb. of water from 100 deg. at 370 deg. And these methods are equally expensive when soda ash is 18½ times dearer than coal. This ratio varies with the efficiency of the fuel and the temperature of the evaporation. In this case, the cost by blowing is cheaper, but I believe it is very debatable whether there is no doubt that soda is a very good remedy against incrustations, and it has been repeatedly recommended by eminent chemists. Unfortunately even this remedv, so simple and efficacious as it has proved, has its drawback, and that of a very serious nature. In a German scienctin
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August 1, 1855.

periodical (Dinger's Journal, vol. 130, p. 183, A.D. 1855), we find it mentioned that Professor R. Froemium had recommended the use of a certain quantity of soda as a certain and cheap means for preventing incrustations, wherever water is used that contains sulphate of lime or (phosphate of Paris). He had used it to advantage, and the results were very good.

The factory boiler in question that formerly was used to be scaled at proportionately short intervals now remains perfectly clean, and even patches of old incrustation too hard for removal had disappeared.

But regarding this, the boiler inspector says: "One continued use of soda attacked the boiler plates very much. Dr. Zimmerman thought that all commercial soda contained more or less cyan, and that is the reason of the corrosion of the plate; Dr. Rudolph Boüe, inspector of another factory, also, in his recommendations of 1853, No. 20, says that he has made several experiments himself, according to which all commercial soda, even from the most respectable firms, contains cyananum, and in consequence of this discovery he warns others against using it in boilers for the purposes of preventing incrustations. It is important to bear this fact in mind at a time when we find the chief inspector of the Manchester Boiler Association recommending the use of soda in steam boilers. Besides it must be remembered that such foreign bodies introduced in the boiler produce a want in all its evils.

5. Blowing off. The original practice at sea was, it is believed, to blow off from the bottom only, which was not found efficacious. Subsequently, additional blowing off from the surface was resorted to, and this has been universally adopted. In America and elsewhere, in order to find Henry Maudsley and Josiah Field, already in 1824, taking out a patent (A.D. 1824, No. 6,021) for withdrawing a fixed quantity of brine by meters of any kind; they preferred a pump with a loaded discharge valve, and the discharge pipes were attached to the main steam pipe, so that the blow-off might be into the receiver. The patent mentions a tubular regenerator for heating the feed-water by means of the heat of the brine drawn off. These brine pumps were at one time used to some extent, but have now been superseded by the surface blow-off, which is the only method of blowing off, or keeping the condenser and the regenerator got choked with salt and thus become inefficient. Blowing off from the bottom has now become almost superseded by surface blowing off, because the latter has been found the more efficient practice. The impurities contained in the sea-water, as much by the application of the heat of the furnace, brought out from the state of the chemical solution into that of mechanical mixture in minute particles, floating about in the hot water and steam, is by the circulation of the steam and water flowing to the surface along with the globules of steam rising to the surface and the heat held in suspension. The heating of steam and water till accumulating to such an extent as to subside to the bottom; or, in their downward course adhering to the surfaces coming in their way. It is hence obvious enough why it has been found advantageous to catch these impurities and blow them off before they can do any harm.

Partly connected with the question of blowing off is that of sediment collectors. Various plans have been proposed for this purpose; but it is a matter of little importance to invent anything applicable as they might be for many other sorts of boilers, they are not in the author's opinion as regards marine tubular boilers as now universally adopted, except in the shape of one or two common scum pans; because any small addition of water into the boiler, stems from the boiler, and, in all cases, the only thing to do is to be sure that the water-room above the tubes, would impede the free circulation of the ascending and descending currents, and thus probably do more harm than good. The author is, however, open to correction in these remarks the boiler men have, in all its internal parts, and this leads to the consideration of probably the most important element in the prevention of incrustation in marine boilers, viz., the influence that the construction of the boiler itself has upon the subject.

If, as has been shown in the foregoing remarks, the sulphate of lime becomes all but insoluble in sea-water at a pressure of 20lb. per square inch above the atmosphere, such as is now commonly used in marine boilers, and if it is a fact, nevertheless, that incrustation can be prevented in many cases, that the more care is taken in the boiler, the more insoluble the material of which the boiler is made, the more amount of care will prevent it in others, then we must arrive at the conclusion that the construction of the boiler, next to the amount of air, is the most important point to the inquiry. You may build marine boilers of very much the same general internal and external appearance to a superficial observer, and still one is a good and the other is a bad boiler to keep clean and to scale. It is obvious that it is only by the rapid and free circulation of the water through the boiler that a vessel can be prevented from being used in any consequence. A vessel that has not found practical in salt water. The chief principle to be aimed at seems this, whenever the greatest heat is communicated to the plates there also ought to be the greatest facility for a rapid circulation, and to be of such a nature that the circulating water, when formed is especially in those most vital, viz., those in which scale when formed is most injurious and dangerous, which are those exposed to the greatest heat. The scanty room generally allotted to marine boilers makes it a difficult task for the designer to meet the above requirements without at the same time losing sight of other important considerations, such as economy and strength. The common multitubular marine boiler may be as follows, and the resulting product, that it gives a little trouble to the engineer in charge to keep clean and scale it: the tubes must not be too close upon each other, and not too many rows in the vertical line, ample room must be left for a man to get in to clean the tubes, and the heating surface must be large enough. The plan of inclining the back tube-plate somewhat so as to allow the steam to escape more freely from the same has found favor with many engineers, and has also collateral advantages. Of late years a multi-
going in to the boiler. To ascertain the proper amount, he takes a measured quantity and adds some drops of solution as long as it makes a milky cloud. The water is then filtered, and some more solution put in, and if no more precipitation takes place find the former quantity is the right one.

W. Danber, 1852, No. 589. This inventor passes all feed-water through filter. 1854, No. 3054. After filtering, he adds powdered charred bones or coal by preference; first, he precipitates lime by caustic baryta, or soluble salts of baryta, including sulphuret of barium, or else oxalate of ammonia. The filtering apparatus is an iron tank with perforated frames, one inside the other; the spaces are filled with powdered charcoal. For certain kinds of engines he adds a mixture of hot water and the filter by means of a pipe for supply of water, and by a small pump he supplies the requisite quantity of solution of baryta to the water as it passes from the hot well. The feed-pumps draw the filtered water into the boiler. To say anything definite against this plan, the filter would have to be of enormous dimensions.

A. V. Newton, 1852, No. 1041. He patents a self acting apparatus for blowing-off, regulated by the density of the sea water itself. A hydrometer floating in the boiler water combined with, and to govern, the motions of an independent mechanism, actuated by a motive force to operate valve and valves which govern discharge of liquid when its density or gravity becomes too great, or vice versa, or the supply of fresh liquid, or vice versa. The hydrometer, by a rather complicated arrangement, acts as a float, the rise and fall of which regulates the opening of the blow-off cock. How this apparatus would fare in a gale of wind, with the vessel pitching and rolling, does not seem to have entered the inventor's mind.

B. Dangerfield and B. Dangerfield, jun., 1853, No. 2696. They employ a conical or cup-like vessel in the interior of the boiler at water line, scum collects in this vessel and is taken off by a pipe at the bottom of the vessel and thence blown off. This is a very old and well known plan.

B. Hall, 1857, No. 1197. He gives a method for preventing the boiler from rusting. He recommends that the boiler be thoroughly steamed before it is put into service, and then thoroughly dried after the water is drawn out.

J. A. Manning, 1851, No. 585. He employs a large cylindrical vessel, placed in the boiler, and connected with the water of the boiler by means of a pipe. The water is kept at a certain temperature, and when the pressure of the steam rises, the water is forced out by the steam. Thus, the water in the boiler is kept in a state of constant, but not excessive, motion, and the impurities are prevented from settling.

J. H. Johnson, 1854, No. 2442. An introduction of sodium chloride and caustic potash into the boiler water is recommended. This practice is said to reduce the scale formation and to improve the efficiency of the boiler.

J. H. Johnson, 1855, No. 2519. Introduction of raw or tanned scraps of hide into the steam generator. For convenience sake a lot is boiled together into a soft mass, and put into the boiler in the shape of a ball, or like scraps of leather enclosed in a bag. It is preferred to use it as powder.

J. H. Johnson, 1855, No. 2592. Introduces air pipes to produce currents, and thus prevents incrustations.

E. Topham, 1855, No. 2030. Applies inside near the bottom apparatus for agitating and drawing-off occasionally, a shallow scraper with one or other of a certain extent. When float in tube limit rises, water bottom is opened with a long blow-off pipe perforated at bottom; by moving the scraper to and fro the sediment is loosened and blown out. The holes in pipe collectively must be less than the area through which the water can pass at the bottom of the tube. A current is produced and the water absorbs matter in vessel and precipitates, and is drawn off by a cock from the very bottom of the vessel.

J. Holt and J. Brown, 1856, No. 1042. This patentee uses a feed water heater, which he also claims a reservoir of mixture for purifying the water; he uses spent tanners' bark, bark knots, &c. C. F. Vasseron. Extract of cheenatt, or any other substance containing gallic and tannic acids.

JOHN C. DURRAN and O. C. CAMERON, 1856, No. 2233. A salometer consisting of two tubes, the ends of which are supported in two cocks; one tube is open, and the opposite one closed; each tube contains a beaded or float adjusted to certain gradations, that in tube "bwo" being the lightest. When density of water reaches gravity of float in tube blow, the same will rise in tube and indicate what more feed should be admitted, but the float in tube and "limi" will not rise till density exceed that of the tube. This apparatus can be used also as a water gauge. The above plan is not unlike Seaward's salometer, patented many years ago.

H. Hobbs and E. Easton, 1857, No. 1516. Solution, or paste, composed of arsenic and soda, or other alkali, when a liquid is to be pumped in, and when a paste is laid on with a brush.

Paul Ingvesen, 1857, No. 1415. Burgundy pitch, alone, or mixed, with one-third charcoal or pure soot, to be applied in boiler while heated.

W. E. Newton, 1857, No. 1949. The black gun catechu is employed. To 5 lb. of this about 4 lb. of ash of the following composition is added: one part of sulphate of copper, one part of copper, and one part of alum. After the ashpits have been painted with the above mixture the boiler is heated. As the water becomes of the colour of pale brandy, small pieces are added daily to keep it at that colour. No incrustation will then ensue. This, he says, does not choke up.

M. Guillaume Didé, 1857, No. 1796. For a boiler of 200 horse-power, suitable for a month.

Crystallised salt of soda .... 60
Potase .......... 10
Lime-scales ....... 20
Tannin .......... 60
Ashes of vine branches .... 60
pine wood ....... 20
Flour of sulphur ....... 6

In addition to these, volatile ammonium may be added to remove incrustations. The above are mixed with the sea water in a paste.

J. Hall, 1857, No. 2015. Sediment collector. A series of plates one inside the other, in which are formed apertures or spaces for the passage of the water and sediment into interior of vessel, the apertures are so arranged that the aperture of one plate may alternate with an obstructing piece of metal in the next plate, and thus overcome the agitation of water passing from the boiler before it reaches the interior of the vessel.

J. Sheddon and J. McVean, 1857, No. 2382. For hardening rock-soda, or carbonate of soda, or soda, or carbonic acid of soda, or soda carbonic acid of soda, or compositions of any or either of them, either as a powder or liquid.

A. and J. Martin, 1857, No. 2945. Crystallised carbonate of soda, wood ashes, and plumbeo mixed and placed in a separate vessel in connection with the boiler. It has already incrustated they propose to add besides hydrochlorate of ammonia.

E. Coulon, 1858, No. 607. Plumbeo and plumbeto of potash and soda, and the insoluble salts of lead and chlorate of zinc, added to a feed tank for the boiler. He prefers to add a quantity of sand, clay, red ochre, and muriatic acid.

H. A. de Saeger, 1858, No. 888. Dryed pitch melted with stearine, or common grease by application of heat; then add wood ashes and ground earth, mix well by stirring; then cool it and make it up into balls ready for use.

J. Braidwood, 1858, No. 915. A vessel connected near the water level and the bottom of the boiler, the bottom of the vessel being lower than the bottom of the boiler, and with an outlet for water. A current is produced and the water absorbs matter in vessel and precipitates, and is drawn off by a cock from the very bottom of the vessel.

W. Allen and W. Allen, 1860, No. 1696. Ammoniacal liquid obtained from it is supported as tar. For a new boiler he paints it inside with several suits of gas tar.

C. J. Dewy, 1860, No. 2988. Sediment collector, consisting of a horizontal tube the length of the boiler, or nearly so, with one end at, or near water level, the other end communicating with the bottom of the boiler near the fire place, by a horizontal pipe. Precipitation by simple gravitation. He says salt does not crystallize till the water is saturated with the salt. If this is not the case, the action is repeated 3 or 4 times. It is thus easy to separate sulphate of lime, first by passing it through a worm heated to 150 deg., or you may have an apparatus for separating carbonate magnesia salts, a second for sulphate of lime, and the other for the separation and exclusion of the salt.

W. Allen, 1865, No. 1472. His patent consists of a boiler with a vertical circular fire-box, with oval cross tubes, whose longest axes are horizontal in the centre and vertical at the end. He also has a plan for a feed-water heater, consisting of a separate tank, serving as foundation for boiler, to stir out, and the heat radiating from the furnace heats the feed-water. This case is divided into two unequal parts by a partition, a cross reaching to within half an inch of the cover or lid, which is to have a thick projecting convexity, to dip at least.
below surface of water when the larger part is fully charged with feed-water. The water expanding at the surface gradually passes over to top of partition to smaller part; the sediment settles in the larger part. He lines or legs inside of shell with wooden staves, to prevent incrustation.

P. Taylor, 1861, No. 2171. He uses pipes with long slots at the surface of boiler, or at the bottom, or both, extending the whole or greater part of the length, communicating with a discharge valve, that can be opened when both feed-water and the water in the boiler are in a spiral slot, causing a rush, which he thinks will prevent sediment.

E. H. Hughes. Twenty-five parts by weight of alum, twenty-five parts of nitrates of soda at 32 deg., two parts of red ochre, three-and-a-half parts of sulphuric acid, fifteen parts of brown fucul of potash and thirty-five parts of distilled water; these are mixed and boiled in a certain way.

A. V. Newton, 1861, No. 2861. Tobacco, as a decoction, or else in a bag.

R. Needham, 1861, No. 2335. A longitudinal pipe at the bottom of boiler connected with the distilling vessel, which is placed in a vertical pipe, and at the bottom of the vertical pipe is an aperture for entrance of mud and sediment, and at top a number of vertical pipes, each with ventilator-shaped funnel at top of water line, with mouth turning towards front of boiler, the flow of water being from the lower to the upper end, and closing these cocks and opening the upper two balls are dropped into the tube, the first ball being adjusted to one degree heavier than the water, is intended to be maintained in the boiler, the second ball one degree lighter; these close the pipe and discharge the water from the boiler.

Now if the density of the water should increase beyond the standard adopted the lower ball would rise, and if it should decrease the upper ball would sink. This is a very ingenious but rather delicate instrument, the use of which has now for many years been superseded by other instruments, the most important of which is still extensively used in many places, and consists simply in a can or measure, sometimes detached from and sometimes attached to the boiler.

This vessel is filled with water from the boiler at certain intervals for ascertaining the density; the can is allowed to cool down until a certain temperature is obtained and found by dipping a thermometer into it, and then the hydrometer graduated to that temperature is dipped in, which, by the degree of its immersion, indicates the specific gravity or density of the water. Such a method is only a rough object of showing the density any time it may be required; but the operation is tedious and requires care, and handling such delicate glass instruments is not exactly the thing in rough weather, when the engineer is engaged in a large number of similar jobs, unless under great pressure to do so.

The next was the introduction of more practical and complete apparatus, the most commonly known of which is that called How's salinometer. His salinometer case contains a separate compartment for the hydrometer and salinometer, and is placed at any time to let in the water from the boiler so as to fill the case, shutting off the communication with the boiler and blowing off the surplus water, if any; the density of the water when the evaporation has ceased, will be determined, but the bubble will soon be cut off, resulting from the reduced pressure of the atmosphere to which the water is now exposed.

The instrument has been and is still extensively used.

A more complete salinometer than the preceding one is the invention of Wexford and the general use of the salinometer.

The objections to How's salinometer are obviated in this instrument by the addition of another separate tube. This latter contains a smaller internal tube, by means of a cock communicating at the bottom with the water in the boiler and at the top with the water in the outer compartment of the inner tube, and a valve communicating with the upper extremity, through which the water can escape in the outer compartment of the long tube or vessel, the steam at the same time freely disengaging itself. The long casing communicates at the bottom with the outer compartment, and is also a part of the hydrometer.

By this arrangement the rush of the water and the violent ebullitions is checked, and thus the density of the water can be observed without danger and inconvenience. But a more convenient and less cumbersome apparatus has been invented by Mr. Gamble, chief engineer of the steamer City of Norwich, has all the advantages of Long's, while the whole apparatus is contained in one piece, thus offering less obstruction, being more sightly, and taking up less space in the engine-room.

This hydrometer is now used only on board the steamer Abigail Mosca. Hayward, Tyler, and Co., of Whitechapel, London. Closing the jam valve occasionally, and then blowing through from the boiler, enables the engineer to clear the supply pipe from any sediment; and this is an important point. The next operation on starting the salinometer is to switch the cut-off valve, and then opening the jam valve, disengaging the steam to the accommodation for the four-way cock so that a line on the plate points straight through from the salinometer to the intake pipe; this helps the salinometer, and allows the water in the supply pipe to work up to its capacity, then closing the cut-off valve. The jam valve is opened about 100 deg. F. A. is the temperature the hydrometer is gauged to. By the regulating screw of the jam valve this can be easily and conveniently obtained, as well as retained. Another great advantage in this practical little invention is that it not only enables the engineer to adjust it much, but is the arrangement of the scales. The indications are given outside the brass face of the instrument, where they can be read off instantly. In conclusion, there is no doubt that after all blowing-off in the proper manner is the best means of preserving the boiler, that there cannot be given the engineer facility enough to do so, and that a salinometer possessing the advantages just described, which are fully borne out in practice, forms the best safeguard against the incrustation of marine boilers.
THE DEMOLITIONS AND EMBELLISHMENTS
OF PARIS.

ANTIQUARIANS who desire to have a look at the last remnants of some of the most celebrated and least savory quarters of Paris must pay an early visit. The clearances for the new hospital of the Hôtel Dieu are sweeping away the rues d’Arcole, Constantine, de la Cité, the quai Napoleon, and the celebrated but wretched street the Rue des Marmousets. The pick-axe has already made its way through the rues Bourbon, Étiennel, Saint Germain l’Auxerrois, and a number of wretched alleys, for the course of the new street which is to lead direct from the Pont Neuf to the great central market. A great portion of the streets bordering on the Halles, with the heavy pillars of the old colonnade, the sites of the birthplace of Molière and of the murdered Henry IV, the remnants of the old monastery and cemetery of the Innocents, are giving place to the new buildings which will complete the great market and connect it with the great circular building in which the corn market is held.

The repairs of the church of Notre Dame are nearly completed. All the side chapels are decorated and furnished with stone altars and statues of the saints to whom they are dedicated. In each are placed a crucifix, bronze and gilt candleabra in the style of the fourteenth century, and other emblems and ornaments. The great doors of the northern porch are just completed. In the centre of the parvis, or place in front of the church, they will erect an obelisk covered with brass, which formerly stood there, and from which the distances on the whole of the great roads through the country are measured.

On the south side of the river another great street to be called the Rue de Solferino, is about to be pierced, and the new Boulevard Saint Germain is to be continued to the Palais Bourbon, in which is the Chamber of the Corps Législatif. These alterations will destroy a large number of celebrated mansions—the hôtel of the family of de Noailles, a fine old house with a noble terrace looking towards the Seine and facing the Louvre; a part of the hôtel of the Duc de Broglie, in the Rue de l’Université; and also that occupied at present by the Popes Nuncio, as well as the whole or a portion of the residences of the families of La Ferté, de Forbin, and de Luynes; the proprietor of the last named, the Duc de Luynes, having had his garden taken for the streets in question, has put up his hotel for sale. On the site of the building now occupied by the Louvre at the Pont de l’Observatoire, it is proposed to erect a palace for the President of the Conseil d’État, which will occupy the angle formed by the new Rue de Solferino with the quay.

The London system of erecting places of refuge for pedestrians at the intersections of wide roads and streets is being carried out in various parts of Paris, where such means are absolutely necessary from the width of the places and the growing increase in the traffic. Many of these refuges are already completed; they consist uniformly of a piece of circular pavilion, having in the centre an elegant candleabra of large size, consisting of a beautiful casting in Florentine bronze, the steps being decorated with ornaments in bas-relief, and supporting five gas lights in elegant oval semi-opaque lanterns, four in a circle and one above; the candleabra stand on circular plinths of the stone of the Jura, between four and five feet in height, ornamented by machinery with bold mouldings and polished. In one place, where occurs the junction of the Boulevards Maloherbes and Hausmann with three streets, there are three of these useful refuges with their beautiful candleabra.

In connection with this subject may be mentioned an undertaking of the Prefect of the Seine, commenced some years since, namely, a collection of all the documents connected with the administration and public works of the city. One object of this bureau historique is the compilation of a work, to be entitled the “Government of Paris and the History of the Préfecture des Marchand,” or trade corporation. An introductory volume has been printed, if not published, containing the plans of the work, by Baron Hausmann, and a note from the Emperor facilitating the prefect on his project of producing a general history of Paris.

PARIS UNIVERSAL EXHIBITION OF 1867.

WEIGHTS MEASURES AND COINS.

On the suggestion of the Metric Committee of the British Association for the Advancement of Science, and of the Council of the International Decimal Association, the Imperial Commission for the Paris Universal Exhibition have resolved to have a special exhibition of the measures, weights, and coins of all countries, and to hold conferences at the same time, with a view to the establishment of one common system throughout the world. The two scientific bodies deputed Prof. Leone Levy to proceed to Paris, to meet M. Le Play, the Commissaire-General and after a conference with the commissioners of different countries, called for the purpose, the Minister of State issued the following ordinance on the subject:

The Imperial Commission, taking into consideration the ordinance of 20th September, 1865, which establishes a Scientific Commission, states:

The Scientific Commission has for its object to concur in extending the use of useful discoveries, and promote reforms of international importance, such as the adoption of the same weights and measures, common scientific units, &c. Taking into consideration also the propositions of two scientific societies in England, propositions which include, first, the project of an international exhibition of measures, weights and coins; secondly the project of a conference, to take place in 1867, for the adoption and extension of a uniform system of measures; and considering the adhesion given to the above proposition by a conference held on the 2nd and 14th May, 1866, to consult as to the means for resuming the labours of the special commission formed at the Universal Exhibition of 1865, has decreed as follows:

Art. 1.—A special place is appropriated in the vestibule of the Palace of the Champ de Mars, to an international exhibition of measures, weights and coins of all countries.

Art. 2.—A special committee on measures, weights, and coins is established in the Scientific Commission to preside over the formation of this exhibition.

Art. 3.—The committee is besides called upon to use the most efficient means for taking advantage of the universal gathering of 1867, for the adoption and extension of a uniform system of measures, weights, and coins.

Art. 4.—To attain this object, the committee will place themselves in correspondence with the persons who have already taken part in the conferences of 1865 and 1866, and the principal persons of all countries whose assistance may be desirable.

The following are nominated members of this committee:—M. Baudrillard, Member of the Institute, Professor at the Conservatoire des Arts et Métiers; J. Levy, Professor of Commercial Law at King’s College, London, Doctor of Political Economy, and delegate to the above-mentioned scientific societies; Mathieu, Member of the Institute and of the Bureau des Longitudes; Pepeot, Member of the Institute, Professor at the Imperial Conservatoire des Arts et Métiers, and Verifier of the Assays at the Mint.

Art. 5.—Other members of the same Committee will afterwards be nominated—persons designated by the foreign commissioners of the states which will contribute to the special exhibition of measures, weights and coins.

Art. 6.—The Conseiller d’État Commissaire-Général is charged with the execution of the present ordinance.

Architectural Competition.—The Architectural Society of Lyons announces a public competition, open to all nations, for a medical college to be erected on the Quai du Prince Imperial in that city. The ground to be occupied does not exceed 6,000 square metres; the plans are to consist of one of the ground floor, one of the upper story, to a scale of five in a thousand, and of an elevation to a scale of one in a hundred. The conditions are to be had on application to the Secretary of the Society, at the Palais des Beaux Arts, Lyons.

* Metric Committee of the British Association for the Advancement of Science; International Association for obtaining one uniform Decimal System of Measures, Weights, and Coins.
Pontoon raised in hydraulic Lift.

Vertical Section of Column showing Position of Hydraulic Press

Scale 5 Feet = 1 inch

Concrete
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

THE HYDRAULIC LIFT DOCKING GRAVEY.

By Edwin Clark, M. Inst. C.E.

The advantages possessed by this system of docking vessels having now been practically demonstrated by long experience at the Works of the Thames Graving Dock Company, in the Victoria Docks, and as other docks on this system are in course of preparation, the Author has thought that a detailed description would form a useful record. The history of the invention dates as far back as 1857, at that time, the Victoria Docks were just completed, and it was part of the Engineer's original plan to construct a graveling dock as an adjunct to that establishment. Plans were accordingly prepared for an ordinary dock, to be lined with brick, and to be emptied in the usual manner by a slide and pumping. The estimated cost of the dock was £90,000. The Engineer—Mr. G. F. Bidder—who, in designing these works, had already introduced many important modifications with a view to economy, was anxious to adopt some cheaper system for docking vessels, of that large class for which these docks were laid out. Among other projects, the feasibility of lining a dock with concrete, timber, or with cast or wrought iron plates, was discussed. Mr. Stephenson suggested a closed pontoon dock, in which the horizontal position and the stability of the pontoon were to be maintained by an arrangement of struts and braces attached to the ground, and forming a parallel motion. The necessary dimensions of these struts, proved, however, to be so great, on account of their excessive length, and on account of the cost to maintain them, that it would be subject, that this arrangement, as well as other mechanical contrivances for securing stability with a submerged pontoon, was abandoned. A similar plan has since been carried out in the London Docks, where a dock on this principle was erected about two years ago. On the first attempt, however, to exhibit in action, the concrete wall was washed away, and the pontoon filled and sank in about 22 feet of water. Some of the rods of the parallel gearing beneath having given way, and pierced the bottom of the pontoon, it was found impossible to raise it again by pumping out the water; and it remained in this state at the London Docks.

Mr. Bidder, finding that no economy could be effected by any modifications of the ordinary dock, turned his attention to a floating dock; and with a view to preparing the necessary plans, requested the Author to visit the principal docks in England, and on the Continent, and to make himself generally acquainted with the various systems then in use.

The Author accordingly gave considerable attention to the subject, and, in conjunction with Mr. Stephenson and Mr. Bidder, various schemes for floating docks were discussed. All were found to be more or less objectionable; partly, from the difficulty of designing such large floating structures with sufficient stability to enable them to resist the steady pressure of the straits, and to ensure that stability of flotation which was wanting in all floating docks then in use; and partly, from their enormous cost. At this juncture, it occurred to the Author, who, under the direction of Mr. Robert Stephenson, had lately designed the machinery, and superintended the raising of the tubes of the Britannia and Conway tubular bridges, that a similar process might, with advantage, be applied to the docking of a vessel. The problem was simply to raise a given weight to a moderate height, in the most rapid and economical manner, and there appeared no reason why a vessel should not be dealt with in the same manner as any other load. The weight actually lifted at the bridge, with only three presses, was equal to that of a vessel of 1,800 tons.

The steady action of the hydraulic press, its extreme simplicity, its small amount of friction, as well as its great durability and economy, render it pre-eminently the best available power for raising heavy weights with low velocity. It is, indeed, more probable than that latter problem, since the press itself originally in all its present magnitude, no other power would have suggested itself; but the progress of dock improvement, like all mechanical progress, naturally kept pace with the requirements of the day, and as ships became larger a simple enlargement of the original rude method was the natural result.

The earliest kind of graving docks is illustrated by the practice of the Greeks, who ran their triremes around on the sandy beach of their tideless sea, and then, dragging them bodily out of reach of the water, surrounded them with earthworks for their protection; an "arsenal" was thus improvised wherever required. A natural improvement, where the ground was suitable, was to prepare an inclined plane of timber to facilitate the operation. Where the tides were available, the vessels were simply beached at high water during spring tides, and when the tide was left high and dry, the following wall was built. The vessel "Great Eastern" was docked in this manner in Milford Haven.

In situations, however, where the formation of the beach allowed of it, a convenient bed or "grave" was dug for receiving the vessel during high water at springs, such excavation being protected from the ingress of the water at the following springs, by an arched bank thrown up in the interval. This was the first Graving Dock. A similar dock is at the present day in use at Hong Kong, the mud bank being protected by basket fascine work. It is remarkable, that not only do all these expedients continue in their original form, but the principles involved have in no way been departed from; and a modern first-class graving dock, even now, differs in nothing, but its dimensions and details of construction from these first models.

The ordinary Dry Dock, at present in use, in tidal rivers, is generally a simple excavation, lined with timber, usually with a brick, or concrete floor, and, to exclude the tide is furnished with a gate, or floating pontoon—first introduced by General Benjamin at Portsmouth dockyard. The vessel enters at high water; the entrance is then closed, and as the tide goes down, the dock empties itself through a tidal sluice, and the vessel settles down on the blocks prepared for it, being at the same time shored horizontally, to prevent its heeling over. The sluice being closed, the returning tide is excluded by the gate, and with a little pumping to keep down the leakage, the vessel is kept dry enough for access. In a tideless sea, a graving dock is precisely similar, except that the whole of the water has necessarily to be pumped out. As vessels increased in dimensions, these docks became important works. They were lined with masonry, the sides being constructed with steps, technically called altars, for the double purpose of affording convenient access and also for the support of the necessary struts for shoring. Pumping machinery on a large scale was added for rapidly exhausting the water, or for rendering the operation independent of tides, and a large amount of engineering skill of the highest order was displayed in improving all the details.

The following are the dimensions of one of these works, just completed at Portsmouth, sufficiently large for docking the "Minotaur," a vessel of 6,921 tons.

<table>
<thead>
<tr>
<th>Length of floor</th>
<th>400 ft.</th>
<th>Width at floor</th>
<th>35 ft.</th>
<th>Depth from coping to floor</th>
<th>99 ft.</th>
<th>Depth at H.W. springs at midships</th>
<th>28 ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ditto at coping</td>
<td>426 ft.</td>
<td>Ditto broad altar</td>
<td>75 ft.</td>
<td>Ditto at coping</td>
<td>99 ft.</td>
<td>Ditto at broad altar</td>
<td>80 ft.</td>
</tr>
<tr>
<td>Granite to the level of broad altar, 18 feet above the floor</td>
<td>135,000 cubic feet</td>
<td>Portland stone</td>
<td>26,750 &quot;</td>
<td>Bricks</td>
<td>3,750,000 &quot;</td>
<td>Concrete</td>
<td>135,000 &quot;</td>
</tr>
</tbody>
</table>

The inclined plane, or slip, has also received its share of improvement. In situations where the foreshore is favourable, it is peculiarly applicable for small vessels, on account of its simplicity. The hydraulic press has been used advantageously as a hauling power, and great improvements have been introduced in constructing the cradles and other accessories. The difficulty, however, of berthing large vessels, and the straits to which they must be liable in being dragged up an inclined rigid plane, on separate and independent frames, supported on wheels, would be a large addition to its use for these vessels. If other mechanical difficulties could be overcome. No slip has hitherto been designed for large ships, and the difficulty experienced in moving the "Great Eastern" down an inclined plane, is a fair illustration of that which would have to be encountered in dragging it up.

It will be seen from what has been states, that a graving dock of large dimensions is, necessarily, a costly work. It must be accessible by a deep channel, and must therefore be adjacent to deep water. In a gravelly soil, or in rock penetrated by fissures, the difficulties sometimes are nearly insurmountable.
A stone dock in such situations not only requires to be as water-tight as a floating dock drawing the same depth, but must be of sufficient weight to remain sunk. This involves in its construction a large amount of material, and the greatest nicety of workmanship; while, even in favourable circumstances, the entrance, with its deep sill and masonry walls, is always a costly work. It was, doubtless, the great cost of such docks, as well as the impracticability of making them at all in some situations, which led to the use of floating docks.

Floating docks have been built of timber and of moderate size; but the introduction of iron for shipbuilding added not only to the increased want of dock accommodation, from the frequency with which iron vessels require painting, but it also rendered more practicable the construction of floating docks of large dimensions. A dock of the earlier description was in use in the harbour of Marseilles, and was managed by the company. It consisted of a timber pontoon with one end moveable; the sides being high enough to remain above water when the floor was sunk sufficiently deep to allow a vessel to float bodily into the interior of the pontoon. In this position, the pontoon was kept afloat by the buoyancy of the sides, which consisted of hollow boxes outlaid water-tight, the vessel being properly secured immediately over the blocks prepared for it. The open end was closed by a moveable gate, and on pumping out the water, the pontoon rose with the vessel within it, which thus became accessible for repair.

An arrangement was also in use in which the boxed sides were dispensed with, by sinking the pontoon on to a prepared platform, the sides being still high enough to reach above the water level.

The same principles were applied to docks of large dimensions, constructed of wrought-iron, and furnished with pumping machinery of the most elaborate character.

In America the system attained further development, there being timber docks on this principle at New York, Charleston, Savannah, Mobile, New Orleans, Portsmouth, and Pensacola. Mr. Stuart, who gives a full description of these works, states, that the American Government attributed great importance to possessing the means of laying up their vessels of war out of the water, and under cover, on account of the rapid decay to which the ships were subject when afloat. They were also anxious to obviate the danger to which large vessels were exposed by being stranded in the operation of launching.

To meet these views the docks at Portsmouth and Pensacola are provided in that, after a vessel is placed on the pontoon, it may be hauled ashore on its cradle, on being afloat, it is drawn afloat by a hydraulic press. Several vessels may thus be placed on the ways, or be launched with a single pontoon. The dimensions of the dock at Pensacola are:

<table>
<thead>
<tr>
<th>Feet</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>390 0</td>
</tr>
<tr>
<td>Breadth</td>
<td>105 4</td>
</tr>
<tr>
<td>Depth</td>
<td>38 3</td>
</tr>
</tbody>
</table>

The total cost was £111,140 for floating dock, £70,645 for basin and subways, £2,600 for floating gate, making £184,385.

The transverse floor girders are effectually trussed. Water-tight bulkheads are introduced, both in the floor and side chambers, and the water is pumped out by two 20 H.P. engines and eighty wooden pumps, placed on the sides of the dock. It was completed in 1851.

There is yet another form in use at San Francisco and Philadelphia, known as the floating sectional dock. The pontoon, instead of being entire, is constructed in separate and independent transverse sections, called "camels," each of which may be used according to the size of the vessel to be docked. The camels are rectangular in form, and are completely submerged, to allow the vessel to float over the keel-blocks placed upon their decks. In order to secure stability in their submerged state, they carry at each end a detached floating chamber, capable of being raised or depressed, by appropriate gearings placed in framed timber towers attached to the ends of the pontoons. As the whole is timber, the camels remain afloat even when filled, and are sunk to the desired depth by raising the floating chambers, their additional weight being sufficient to sink the sections, and to maintain their stability at the same time. The water is pumped out of the camels till the vessel rests on them. They are then ground in a basin prepared for the purpose, and the vessel landed ashore as before.

The dock at Philadelphia is 382 feet wide, 105 feet long, and drawing 10 feet of water with a large vessel upon them. When used together, they form a dock 300 feet long, and 105 feet wide. Their total displacement is 5,800 tons, and the cost was £170,000. They are emptied by two 20 H.P., and one 12 H.P. engines, working three pumps at each end of each section, with moveable shafting.

Floating docks are necessarily limited in their use, not only by their enormous cost in construction and manipulation, but also by their great liability to accident from the slightest mismanagement. The raising of a vessel on such a machine as that just described is really a difficult engineering operation in itself. The dock at San Francisco was seriously damaged, and Her Majesty's ship "Termagant" nearly capsized in a recent attempt to place it on the camels.

The loss of the floating dock in the London Docks has been described, and a similar action happened to that made for Sobra Bay, Java. A large dock, erected at Rio Janeiro, was flooded and utterly destroyed by a single flood. The fatal disaster which occurred with the dock at Callao will be fresh in the minds of members, and indeed the history of a large number of these docks is notoriously a history of failures or disasters.

The Thames Graving Docks.

It was with a view of meeting, as far as possible, the objections to existing systems, that the Author proposed the Hydraulic Lift Graving Dock as the most efficient and economical substitute for the requirements of the Victoria Docks.

It was ultimately constructed by a totally independent company under the name of "The Thames Graving Dock Company." The necessary capital, originally £250,000, was raised in shares of £1,000 each, and was privately subscribed.

The site selected was a plot of 26 acres of level land, lying between the Victoria Docks and the Thames, and below the level of high water. This site admitted of a direct entrance from the Docks, with a permanent water level, without the cost and expense of a deep bed of bog and alluvial mud, on a substratum of gravel. The only excavation necessary was the lift pit, and its deep entrance to the dock, where a cofferdam was employed.

The depth of water in the lift is 27 feet; over the remaining water space it is only 6 feet, which is the maximum draught of two of the docks. In all there are eight pontoon berths, separated by jetties for workshops and access; each berth being 60 feet wide, and from 300 feet to 400 feet long and surrounded by brick-retain ing walls. The bottom was covered with a level layer of pea clay, to prevent leakage to the gravel beneath. A sluice through the surrounding bank renders it easy, at low water, to empty the whole of the space; but when this is done, a dam must necessarily be thrown across the upper end of the Dock, to cut off the access to the Victoria Docks. The area of shallow water is 16 acres, affording sufficient space for floating fifteen or twenty pontoons, which, it was estimated, was about the number that could be displaced by a single lift.

The docking of a vessel consists of two distinct operations. First, the direct raising of the weight on the lift; second, the transportation of the vessel to any convenient position for its repair on the pontoon.

The lift is a direct mechanical appliance for raising the vessel by means of hydraulic pressure. It consists of two rows of cast iron columns, each 5 feet in diameter at the base, and 4 feet in diameter above the ground-level, and sunk about 12 feet in the ground. The clear space between the two rows is 60 feet, and the columns are 20 feet apart from centre to centre, and are placed on each side of the excavated lift pit, in about 27 feet of water. There are sixteen columns in each row, giving a length of 310 feet to the Dock; but, as vessels may overhang at each end, there is a practical working length of 360 feet. The columns were sunk in the usual manner, three or four being fixed per week. When the requisite depth was attained.

*Note: "The Naval Dry Docks of the United States."
the base was filled with concrete, and covered with a layer of 2 inch planks, to act as a cushion for the cast iron seat on which the press rests. No great accuracy of position is required, as the suspended load tends to bring all the columns vertical, and if any column should, during the pressing, begin to lean to one side, the ram returns it to position. The ram is driven down into the soil, the ram follows its work, independent of the level of the press. The columns support no weight, but act solely as guides for the cross heads of the presses, which move in slots reaching from the top of the presses (just clear of high water) to the top of the columns. The column is covered by a cap, and each row is firmly connected at the top cross head. An iron framed platform, running from end to end of the Dock on each side. This platform forms a convenient permanent scaffold for raising the rams. The whole length of a column is 68 feet 6 inches. A scale is printed on each column to register the motion of the cross heads while rising or falling.

The presses and girders are managed as follows:—Each column encloses a hydraulic press of 10 inches diameter, with a length of stroke of 25 feet; the top of the press is just clear of the highest water, and it is kept in place by a collar or diaphragm in the column. The rams are solid, and each carries a boiler plate cross head 7 feet 6 inches long, thus extending 1 foot 9 inches beyond the column on each side. From the top of the cross head are suspended, by wrought iron bars, two iron girders each 66 feet long, which extend entirely across the Dock to the corresponding column and press on the opposite side. There are thus sixteen pairs of suspended girders, lying at the bottom in 27 feet 6 inches, on the press and appearing but rising above the surface, when the presses are raised. These are the large wrought-iron platform, or gridiron, which can be raised or lowered at pleasure, with a vessel upon it. The detail of the machinery is identical with that employed at the Conway Tubular Bridge; and those who saw that bridge raised have only to see the three twenty-two girders of this, and they will have a perfect representation of the lift. The main girders are 6 feet 9 inches deep, of wrought iron trussed with a cast iron top flange. The sectional area of each ram being 100 circular inches, a pressure of 2 tons per circular inch gives 2,000 tons as the lifting power of each press, or 6,400 tons for the whole, if the available lifting power, there must be deducted 620 tons, which is the weight of the rams, cross head, chains, and girders, leaving 5,780 tons for the pontoon and vessel. The presses were tested at 2½ tons per circular inch. The girders are designed for carrying the vessel as a load at the centre, although the load is distributed by the pontoon, and the weight of the block or the block. The ship is forced into the presses immediately beneath the collars at the top, this being an accessible position.

The grouping of the presses was an important consideration. If each press were worked entirely independent of its neighbours, it is evident that precisely the same quantity of water must be thrown into each press to avoid unequal strain. Again, if the whole number were supplied from a common head, the slightest excess of weight at any part of the platform or gridiron would lower that part, the water passing back through the pipes to the presses where less pressure existed; the same difficulty would be experienced with two groups, however arranged. Stability is, however, secured by arranging the presses in three groups of one half of the whole number, occupying the upper half of the lift, form one group, consisting of sixteen presses. The remaining eight presses on one side form a second group, and the opposite eight form the third group.

The presses in each group are all connected, so that perfect uniformity of pressure is secured in each and regards the individual presses; while the three groups are so arranged that their centres of action form a tripod support, upon which the pontoon is seated. As any one point of the tripod may be raised or lowered without regard to the other two, by the most simple manipulation, the pontoon can be either maintained perfectly level or can be altered or to contain the vessel intended to be docked, and are rectangular in form, and open decked. The sides are vertical, and are strengthened longitudinally and transversely by wrought-iron girders, running from side to side, from front to end, and thus forming a series of rectangular divisions. The pontoon is divided into compartments by the bolting of the girders, each compartment being provided with a circular valve in the bottom, closed by a screw-shaft. The transverse girders are 8 feet apart, and support the bilge-blocks on their upper flanges. In the largest pontoons these girders form inclined planes, declining in height towards the centre, to facilitate the running-in of the block-frames. There is a strong longitudinal centre girder, with a broad top flange, for supporting the keel-blocks; on each side, the two other longitudinal girders are

other groups, vessels, partially raised, descend slowly and steadily into the water.

Additional provision against such a contingency has been provided, by an arrangement which gives instantaneous means, in the event of the house of being wholly or partly immersed. For this purpose, a special series of valves is provided for each group, which can be closed simultaneously, by means of an eccentric shaft. This arrangement, which forms so prominent an object in the valve-house, has been found unnecessary, and will not be again employed. The force-pumps, which have been described, driven by direct action by a 40 H.P. engine, six of these pumps are used for the large group, and three pumps for each of the smaller groups. The power when required is increased by cutting one or more of the pumps. The engine-house is, unfortunately, 112 yards from the lift, and the water is driven to be driven all this distance through pipes only 4 inch in diameter. On account of the distance of the engine, a valve-house, for the manipulation of the presses, is erected on the platform alongside the Dock. During an operation the engine continues to pump, and the valve-man throws the water into either group, or to waste, at pleasure. The raising of a vessel occupies about twenty-five minutes. The pipes and presses are, to a considerable extent, still better by the formation of the engine; and during the severest cold, a few occasional strokes of the engine are found sufficient to keep all in motion, and prevent congelation.

The pontoons are not essential for raising, or docking a single vessel; it is evident that the lift, as described, is all that is required for that purpose. To give a further support, connected together by other longitudinal girders, so as to form a sufficiently rigid platform, or the whole might be formed into a pontoon, which would support a vessel after it was raised. Such an arrangement would be more economical and convenient than any hitherto made, but it is not possible to do so unless the vessel is a very small vessel; whereas, by the use of separate pontoons, an indefinite number of vessels may be placed afloat, whilst the most costly part of the system remains constantly available.

The following is the arrangement adopted:—An open pontoon, proportioned to the size of the vessel to be docked, is selected. Keel-blocks are set in position, and the vessel is placed on the pontoon, which is placed on the girders, and sunk with them to the bottom of the dock. The vessel is brought between the columns, and moored securely over the centre of the pontoon. By lifting the girders, the keel-blocks are first brought to bear under the keel of the vessel; the side-blocks are then hauled by chains on the pontoon, and the vessel is raised, and the gridiron and the pontoon, with the vessel upon it, are then all raised by the presses clear of the water. The pontoon is provided with valves in the bottom, and thus empties itself of water. The valves are closed, and the girders again lowered to the bottom, but the pontoon, with the vessel upon it, remains afloat. Thus, in about thirty minutes, a vessel, drawing 18 feet of water, is left afloat on a shallow pontoon drawing 4 feet or 6 feet, and may be taken into the shallow dock prepared for its reception. These docks are surrounded by workshops and tools, with shelter for the men close up to the bulwarks of the ship. The vessel is, in fact, brought bodily into the centre of a covered valve-house, and all of the essential repairs can be accomplished there, or the machine shops, according to the nature of the repairs required, and is moved easily from one to the other.

The number of vessels that can be thus docked is limited only by the number of pontoons, each pontoon constituting a separate and independent dock. The pontoons, which are all about 65 feet wide, vary in length and depth according to the size of vessel intended to be docked, and are rectangular in form, and open decked. The sides are vertical, and are strengthened longitudinally and transversely by wrought-iron girders, running from side to side, and from front to end, and thus forming a series of rectangular divisions. The pontoons are divided into compartments by the bolting of the girders, each compartment being provided with a circular valve in the bottom, closed by a screw-shaft. The transverse girders are 8 feet apart, and support the bilge-blocks on their upper flanges. In the largest pontoons these girders form inclined planes, declining in height towards the centre, to facilitate the running-in of the block-frames. There is a strong longitudinal centre girder, with a broad top flange, for supporting the keel-blocks; on each side, the two other longitudinal girders are
The cost of the lift and other machinery was: 20,300

The 50 H.P. condensing engine and pumps, boilers and connections, including the valve arrangement, (not a necessary part of the apparatus) 3,600

The connecting pipes, including all testing, fitting, and fixing, supply of workshop tools, experiments, &c. 1,628

It may be remarked that, a high-pressure engine would be more convenient, and far more economical.

There are, doubtless, many details which may be materially improved after seven years' experience; but it is a proof of the simple character of the machinery, that no modification, or renewal, or repair of any kind has been necessary, although, at the end of last year 1,055 vessels had been lifted, of an aggregate tonnage of 712,380 tons, without a single casualty.

No remark is necessary on the calculations employed in so simple a machine; each pump being 21 circular inches, their aggregate area is 42 circular inches. Similarly, the aggregate area of the thirty-two pipes is 3,200 circular inches. The action, disregarding friction, is therefore identical with that of a lever, whose arms are respectively 42 and 3,200. The respective velocities and pressures are thus obtained by direct proportion, the power being a 50 H.P. engine on the long end of the lever, and the weight lifted being the vessel on the short end; while it may be remarked, that, in a stone dock, the power employed bears no proportion to the work done, and is always immensely greater.

As regards the advantages of this pontoon, it will be seen that it differs, in many respects, from an ordinary pontoon. In the first place, it is open without a deck; the sides are no higher than is required for the load; it is not encumbered with any pumps, or machinery, or inaccessible chambers; when submerged, its stability is ensured by the pressure, and, when afloat, its form gives the greatest amount of stability possible; while the simplicity of its construction renders the cost extremely moderate. The durability may be estimated from the fact, that the effect of seven years' wear and tear is imperceptible, although, during all that period, the pontoons have never been repaired.

The pontoon affords special facilities for blocking vessels, and for access to them when blocked. This arises from the clear space which the open deck of the pontoon affords for blocks and scaffolding, and from the fact, that the keel of the vessel is everywhere accessible, on account of the deep space beneath it. This peculiarity has been found of great value, since the renewal of a keel, in an ordinary dock, is a work of great difficulty. There is, however, no feature of greater importance than the absolute freedom from strain afforded by the partial elasticity of the pontoon, and the means of balancing it by admitting water. To appreciate this, it must be borne in mind that the object in supporting a vessel out of water should evidently be to replace, as precisely as possible, the pressure which the water affords, when she is afloat; that, for instance, a stone dock is too deficient, and the effect on large vessel so disastrous. An ironclad vessel weighs about 20 tons per foot run; but, if divided into a series of transverse sections, the support at every section will be equivalent to the displacement of that section. At the centre of the vessel, where the bulk is large, it will be much greater than at the bow and stern; but when supported on the rigid floor of a stone dock, the stiffness distributes the weight nearly equally, over the whole length of the keel, looking at the ship, then, as a girder, and the buoyancy, or the supports, as loads laid on the girder is evidently, in both cases, subjected to totally different strains. The superior buoyancy of the centre of a vessel frequently shows itself by the bog-action form it assumes, or by the wrinkling of the copper, and, in an ordinary dock, this last appearance, not unfrequently, indicates the strain to which vessels are subjected.

Again, the bottom of a stone dock is a narrow floor prepared for the keel-blocks, with no means of support under the sides of the vessel, where the whole weight is concentrated. As the water is lowered, the vessel rests first solely on the keel, and the enormous and injurious strains, thus thrown on the ribs of an iron-plated vessel, may be imagined. Indeed, no greater departure from the support previously afforded by the water can be conceived. It is true, that the forest of struts always placed between the vessel and the walls on each side, do, to a great extent, replace the horizontal pressure of the water, by tending to push the sides together; but without a vessel could be so docked at all. But the Author need not point out to Engineers, that in dealing with a weight of 20 tons per foot run, no vertical support of any value can be obtained by struts, which must of necessity be nearly horizontal, and which, when slightly inclined, have been known to disturb the solid masonry steps of the quay itself. As soon as the greater part of the dock, proper shores are added under the bilges, but the mischief is then done, and the quantity of timber consumed in these blocks and shores is, alone, an item of cost many times greater than the whole expense of docking such a vessel on the permanent blocks of a pontoon. The whole current cost of the latter operation, including the preparation of blocks, coals and staff, does not average £3 per vessel, in the Thames Graving Docks; and it is performed as follows:—

The permanent keel and bilge blocks are first packed up with reference to the form of the vessel, and secured together with “dogs.” The bilge blocks move on sliding frames, and as soon as the keel touches the pontoon, the frames are drawn by chains down the channels prepared for them, and are thus made to abut solidly against the ship in a position nearly vertically beneath the sides: a ratchet prevents their return. The vessel is thus fully blocked before being lifted, and, when lowered again and left afloat, the elasticity of the pontoon secures an equable bearing in any bottom block, and does not cause any harm to its neighbours. The vessel is supported at numerous points, by pressures analogous to the pressure from the water itself: it is also resting on a base 30 feet, or 40 feet wide, so that without shores its stability is beyond all question.

Again, the support rendered proportionate to the displacement, by admitting compartments, as in the American Floating Dock; thus any excess of pressure shown by the blocks is immediately remedied. When the pontoon is longer than the vessel, the end compartments are invariably left open, and only that portion of the buoyancy of the pontoon is retained which the circumstances require.

The stiffness of a pontoon depends on its depth. The amount of longitudinal stiffness necessary for a pontoon when afloat is very small; for, if the balancing by means of the water is properly regulated, no strain is thrown on the vessel from deficient rigidity. It is indeed evident, that if a pontoon were perfectly elastic, and if of a sufficient length, the strain in it would be absolutely identical with the strain in the water. It is however advisable that the strength of the pontoon, laterally, should be nearly sufficient for supporting a vessel resting entirely on the keel-blocks, as the bilge-blocks are necessarily removable. It is also necessary to retain a considerable amount of longitudinal elasticity, on account of the uniformity of the lifting force; this is, however, modified by cutting off one or more pair of intermediate presses; and in docks which are now in preparation, the presses are not placed at equal distances, but nearer together at the centre of the lift than at the ends. The same result may be obtained by slightly increasing the area of the centre presses. The whole subject of blocking is full of practical interest, and nothing will excite more attention, in a visit to the Docks, than the extreme facility with which the operation is performed.

* No. 1 pontoon was framed with wood in its outer compartments, and only built a foot high, the walking being afterwards added.
and the ease with which a single operator appears to handle these, apparently, unwieldy structures.

It is unnecessary to dwell on the subject of the stability of the pontoon itself when afloat: the author would only observe, as the result of calculation, that the effect of a gale of 20 lbs. pressure per square foot on the broadside of a frigate, with every sail set perpendicular to the pressure, would be an extra immersion of only 1 feet on the lee side of a pontoon. In practice, no gale ever produces any appreciable motion whatever.

Although, however, the tilting effect is inappreciable, yet during a gale of wind the navigation of a vessel, on the deck of a pontoon, requires proper caution. This was illustrated by a singular accident, which occurred during the great gales of 1860. A vessel, which had been there before, was then to take on board along the jetty across the open dock during the height of the storm; the rope gave way, and the pontoon, with the vessel upon it, drifted, with rapidly increasing velocity, entirely across the dock, when it came in contact with two empty pontoons, lying alongside the jetty. The immediate effect was to stave in one of the compartments, which filled, and the pontoon rebounded back some distance into the dock; the wind, however, catching it a second time, it again struck the pontoons and unfortunately staved in a second compartment, and sank. The vessel, however, remained upright and uninjured on the blocks. The operation of floating it again was characteristic of some of the advantages of the system. A low dam was raised across the upper end of the dock, in the shallow water, and a few feet of water were run out of the dock, by means of the sluice. This was sufficient to expose the side of the pontoon above the water, the damaged plates were then made tight with clay, and on pumping out the remaining water in the pontoon, it was left afloat again, and placed on the lift till it was needed.

As to the practicability of enlarging the system to meet the requirements of vessels of any size, it is evident that by simply placing an additional column between every existing column in the present lift, the lifting power would be doubled, or made 64,400 tons, with out altering the strain of a single bolt. The same result might be obtained by placing a similar column, and this was the form adopted in the designs prepared, by order of the Lords of the Admiralty, for vessels like the "Minotaur." The lifting power may further be indefinitely increased by enlarging the area of the presses, and no mechanical difficulty would be experienced, with even ten times the weight alluded to.

Again, the weight that could be lifted may be doubled, without any alteration of the presses, by using a close-decked pontoon instead of an open one. An additional lifting power equal to the displacement of the pontoon would be thus obtained by pumping out the water, and the power would ensure the filling of the lift, and complete the operation. A dock in this form was also designed for the Admiralty on their official request; but it is evident, no advantage could result from the substitution of the pontoon as a partial lifting power: it is, in any form, a far more costly arrangement, and its combination with the presses removes none of its disadvantages.

Although no doubt can exist as to the capability of the lift to deal with any required weight, the Author feels bound to state, that some doubts have been expressed as to the expediency of docking vessels of the largest class on a pontoon without the ordinary horizontal shoring, which forms so prominent a feature in an ordinary dock, and which would be naturally looked upon with reluctance by an old shipwright. There are, moreover, some localities where the docking of the largest class of vessels is so rarely required, that the cost of a special pontoon is scarcely warranted: an arrangement has accordingly been perfected which will fully meet these requirements. Altars or steps might undoubtedly be placed on a pontoon; but to secure an efficient base, a considerable increase of width would be necessary, as well on the pontoon as in the main girders of the dock. The requisite base may, however, be obtained by projecting the lifting girders beyond the columns, on each side of the dock. It is further proposed to combine them by longitudinal girders, and then, by a close place in the whole external girders so as to enter the gridiron into a water-tight pontoon, with framed altars on each side, of sufficient height to remain above water when the pontoon is sunk. The presses would then lift an entire floating dock, of the ordinary form, which, when raised, would remain afloat, independent of the presses, but be capable of being moved from its fixed position.

Smaller pontoons might be used in the ordinary manner, by lifting them on the top of this fixed pontoon. This would afford efficient means of storing the ordinary way, and effect some economy as regards the construction of an independent large pontoon; inasmuch as the main girders of the dock would take the place of the transverse girders that would be required for the pontoon. This arrangement is specially applicable to places where only a single dock is required.

Numberless other modifications suggest themselves. The pontoon may be used in any ordinary dock, or in a tide-way where the rise and fall is sufficient, without a lift at all. The tide may also be made available in diminishing the stroke of the presses to the extent of its rise. The lift may be erected in any open dock, and the water from the basin used to fill the dock. An entirely new character of the soil—the only limit to its application is in places where the depth is too great for fixed columns; but even for these situations a modification has been devised by Mr. W. H. Walker, which possesses great merit. This gentleman proposes to float the presses themselves, on a series of pontoons, employing machinery very similar, in many respects, to the described. The dock thus becomes a moveable floating dock, capable of being moored anywhere, and of its position being changed when desirable. It is also very portable in its parts.

In conclusion, it must be admitted that however successful this system may have proved in a mechanical point of view, its early adoption was accompanied with the greatest difficulties. The first misfortune, which befell the Company at starting, was the irreparable loss of its Chairman, the late Mr. R. Stephenson. The Company had commenced with insufficient capital, and before completing their works, they found themselves deprived of the master mind, on which they were so much accustomed to rely. They based no large hopes—on the contrary, were anxious to rely solely on the dues from docking as a means of revenue; they were surrounded by numerous competitors, on each side the Thames; and to such an extent was competition carried, that the docking of vessels was, for a long time, performed in the Port of London without all charge whatever being made for docking. As the officers of the Company were restrained, by strict instructions—issued by the direction of the leading proprietors—from undertaking repairs, or entering into any mercantile arrangement, they were helpless. And it was seldom that even half the amount of the intended charge for docking a vessel could be obtained, though that charge was only a tax for the lifting, and 2d. per ton per day for the use of the pontoon. It then became evident that the only alternative was for the Company to entirely change their system of business; to become themselves manufacturers, and to do all repairs, &c. The immediate result has been successful beyond expectation. The Company now possess one of the most perfect and extensive ship-repairing yards in the kingdom, with spacious workshops, and abundant machinery for every class of work. The weekly payments, for labour only, reach £1,000, and although they now possess seven pontoons, equivalent to seven distinct graving docks, yet, to meet the increasing requirements of their trade, others are being constructed. The number of vessels that resort to the establishment is increasing, and among them are included some of the largest vessels that frequent the Port of London.

The principal features of the system may be conveniently summed up, as follows:—

1st. Its economy, as well in its first construction, as in its subsequent maintenance.

2nd. Its adaptability to almost any situation, especially in harbours or tidelakes.

3rd. The capability of almost indefinite extension, by the construction of additional pontoons, or as regards the lift, by the addition of extra columns.

4th. The simple and durable character of all its parts, and their economy in perfect accessibility.

5th. The short time required for its construction and erection.

6th. The rapidity of its manipulation, and the small staff required.

7th. The convenient access afforded to all parts of the ship, and, especially in painting iron ships, their free exposure to light and air.

8th. The freedom from strain with which vessels, even in cargo, may be docked.

9th. The means afforded of rendering any area of shallow water available as a dock for the largest vessels.

58
THE ARCHITECTURAL ASSOCIATION.

The last meeting of the Session of this Association was held on 20th June, Mr. R. W. Edia, the President, occupied the chair. Mr. C. H. Hargreave, Mr. Alexander Payne, and Mr. B. Bird, were elected members of the Association.

The President read a letter from Mr. Ashpitel, expressing regret that the Royal Institute of British Architects had declined to award a medal to those who had passed the Voluntary Architectural Examination, as suggested by the Committee of Examiners. It was satisfactory, however, that other of the proposals which had emanated from the Architectural Association had been adopted.

The following paper was then read:

ON ORNAMENTAL IRONWORK.

By CHAS. H. F. LEWIS.

Among the many arts that flourished in the times of our forefathers, some of which have been revived in recent times, the art of the blacksmith, the ever-favourite theme of the painter and the poet, is one which has received from us the least amount of study and attention. This is denominated an iron age, but it is certain that in the early days of our country iron was used for an infinitely greater variety of purposes than at present, and that in every article, however unimportant may have been its use, some traces of a feeling for ornamental art were displayed.

Although the Exhibition of 1851 was regarded by many as the harbinger of universal peace and ironwork, neither of these predictions has been fulfilled. Much has been done of late towards improving the character of ornamental ironwork by some of our enterprising metal-workers, for which they deserve the highest praise, but unfortunately there is such a painfully machine-made look about even some of their best hand-made work that I think the true revival of working in iron has yet to come. Of course I do not refer to such chef-d'œuvre as the Hereford arcades, a specimen of a similarly pure and characteristic but to the ordinary every-day productions for ecclesiastical and domestic use.

Our railway engineers, the ironclasts of the nineteenth century, have much to answer for in their wholesale abuse of this noble and national material, and I may safely say that in no other country in Europe would such monstrosities have been allowed to be perpetrated as are continually being erected in our metropolis—monstrosities not only painfully visible to the educated eye, but condemned by even those who have not the slightest shadow of a pretension to art knowledge. There must be something woefully wrong in the education of our engineers to lead to such increasing depravity of taste and total disregard of appearances and of application. The effect of their prolific fitness for the work they are intended to perform, and present a strong contrast to the clumsy masses of material piled up by our civil engineers. This would lead us to infer that the science involved in modern engineering works is of a very doubtful character; and this conclusion is rather strengthened by the failures constantly taking place in such simple matters, for instance, as a row of brick arches to a railway viaduct, even before a rail is laid or the parapet is on, which accidents are generally very complimentarily attributed to an extra shower of rain, or something equally absurd, and never to want of care on the part of the engineer. To my mind there does not appear to be much more science in suspending those Leviathan iron tanks called railway bridges, between two dead walls than in throwing a log across a mountain stream. Our engineers may have been spoiled in some measure by the twaddle that is occasionally written in our leading journals in praise of their large public works; for what can be worse than to be told that the hideous iron pipes of the Charing Cross Bridge remind one of the propellers of the crude vessels of military engineers are equal, if not superior, to the works of Michael Angelo. It is to be regretted that in so few words Mr. Fowler, in his opening address before the Institution of Civil Engineers, should have dismissed the subject of architectural art in engineering works, and had not a word to say in condemnation of the abortions in iron designed by some of his contemporaries.

It is scarcely necessary to refer to the necessity of designing ironwork with a character peculiarly its own, and not in imitation of the features of wood or stonework, and that it should be in keeping with the architecture of the building of which it is an adjunct. Not one who would now be guilty of the anarchisms committed a few years since, or who would perpetrate such things as were done by a church architect of some thirty years ago, one of whose favourite arrangements was to make his apparently massive oak doors of a mixture of deal and cast-iron, the framing being of deal, and the cupping and mouldings to the parapet being of casts of oak screwed on the whole being grafted in the most artistic manner to represent oak. One of the latest and most important examples of what to avoid in this direction (and in which we have to regret that a good opportunity was lost for showing what might be done in the consistent treatment of ironwork), is afforded by Westminster Bridge, every single arch being decorated as if stonework.

Whatever difference of opinion may exist as to the merits of other portions of medieval architecture, there can be no question as to the superlative excellence of its metal work, and of the true principles worked out in the best periods of it; it is only in the latest specimens that we find imitations of the treatment of other materials.

Ironwork is often made to appear too heavy in execution, from the designer judging of the effect from geometrical elevation only, and forgetting that when seen in perspective, the interstices become smaller, and the bars become larger, from seeing two faces of them, if square in section, instead of only one, as in the elevation, and consequently the proportions of the whole thing are entirely altered. This mistake is more easily perceptible in wrought ironwork where the iron is generally used of an oblong section for strength, shewing the narrow edge on the face. Many cases have come under my notice where designs, otherwise good, have been spoilt from this failing, when carried into execution. I once received a design, for instance, which, from this peculiarity, and ironwork ought also to be designed with special reference to the position it is intended to occupy. For instance, when seen against the sky, surface treatment is of course unnecessary, and a much lighter and more delicate character ought to be adopted for internal use.

It is as well to remember that the heaviest ironwork is not always the strongest, and that the requisite amount of strength may be obtained by a proper distribution of the constructive...
parts of the design. The numerous examples of good ironwork to be found in London alone are such as to make our present deficiencies in its art treatment still more inexcusable, and we have only to cross the Channel to see what a revolution has been effected there during the last ten years in metal work generally, for one cannot walk a dozen yards in the new quarters of Paris, or the large streets of France, without meeting at that time proper and worthy attention to the design of the ironwork, the shape of the railing to a square enclosure, balconies, balconets, window grilles, &c., for the most part of wrought iron, where the lines of the design bear the impress of careful study on the part of the designer, and do not look as if they came out of an ironmonger's pattern book. The controls, the shapes and its very pathetic character with some carving, and details generally of the architecture of Napoleon III, which would in some respects be improved by greater boldness of character, are the attributes particularly suitable to good ironwork.

It is curious to see with what pertinacity we adhere to the old stereotyped form of railing for our parks and squares, consisting of upright bars, top rail, and the everlasting spike-heads of the approved wardlike pattern, and the same sort of thing, on a smaller scale, for the areas of our private houses, which makes the basements look more like the dens of wild beasts than the abodes of human beings.

As to the procedure of the ironwork itself, I will refer to the distinctive features of some existing specimens of good ornamental ironwork. The elaborate wrought ironwork executed in the reign of William and Mary, for Hampton Court Palace, by Huntington Shaw, of Nottingham, is, or ought to be, well known to every architect. Some of the best portions of it were taken away from the railing which separates the river Terrace from the Home Park, and deposited in the South Kensington Museum. This ironwork is believed by some to have been designed by Sir Christopher Wren, but I think there may be doubts upon this point, as the smiths of Nottingham have always been celebrated for their work, and the execution of these gates is of such a superlative character that it is highly probable the design was designed by the workman himself. The design of these gates is noteworthy for the clever way in which heraldry is made to play its part in the general effect. In the centre panels of those preserved at South Kensington we have the rose of England, the thistle of Scotland, the harp of Ireland, and the royal monogram arranged in the most charming manner. The bold and graceful lines of the scrolls and foliage which make up the rest of the design afford good evidence of the perfection which the blacksmith's art had attained at that time. It is in the wrought ironwork of this period, both in England and on the Continent, that we find such elaborate imitations of natural forms in foliage combined most artistically with the conventional forms.

The introduction into ironwork of armorial bearings, monograms, and dates of erection, should be encouraged at the present day, as it would add a material amount of interest to the work. The English wrought ironwork of the first half of the last century, of which there is a great deal existing in London and its suburbs at the present time, deserves our attention for the very simple and honest methods by which a really good effect is obtained in most instances. The designs generally consisted of very light and elegant scrolls, with foliage of a purely conventional character, almost not to interfere with the lines of the scrolls. Our domestic buildings of this date had very little architectural art externally, except in the shape of ironwork, and what there was of it internally, was confined to the wrought iron staircase railings, the chimney-pieces, and the ceilings. The fine gates to be found in our Inns of Court, and attached to some of our country mansions, belong to this period, but the best example I know of is to be seen in the Armoury House of the Honourable Artillery Company at Finsbury.

The excellent museum of antiquities at Rouen is particularly rich in specimens of good French wrought ironwork. The most perfect of which are a pair of gates formerly in the cathedral, and is a first-rate piece of wrought workmanship. Although of the very lightest character, the diagonal arrangement of the filling-in bars, which is seen very often in medieval work, gives a wonderful amount of stiffness. These gates belong, I believe, to the beginning of the fourteenth century. A slight sketch of them appeared in the Builder some years ago, but on too small a scale to give any idea of the originals, and in the paragraph attached to the sketch they were assigned to the twelfth century, which I think was a mistake, as they bear the character of a much later date. Another good example to be seen in the same museum is the frame of a doorgrille of the fifteenth century, which came from a convenant near Rouen, and exhibits a very effective mode of treatment at that time. The use of wrought iron for this purpose was quite common in those days, and placing behind them red leather, or sometimes red cloth. This treatment is often seen in the lock-plates of old chests. No student who visits Rouen ought to fail to see its museum, as nearly everything contained therein will be found to bear some relation to architectural study.

The references I have included in bringing my remarks a few more examples of the ironwork of medieval times, but those periods have been so well and thoroughly illustrated in the works of Digby Wyatt, Waring, Pugin, Parker, King (of Bruges), Raymond Bourdeaux, and many others, that I cannot do better than refer any one wishing to study the subject to those books; of course personal study of the objects themselves is better still, but the advantage of their works is that they furnish the key to the mine of wealth in artistic wrought ironwork open for our exploration in England, France, Italy and Germany. I may, however, refer to the beautiful screen of Queen Eleanor's tomb in Westminster Abbey, which will repay any amount of study, both of its workmanship and its design. How little is known of the art. Had it not been happily rescued from oblivion by the hands of Mr. Scott, and restored to its original position, it is very probable that it would have shared the fate to which numberless other such ecclesiastical antiquities appear to be doomed by the ignorance or culpable negligence of their appointed guardians. An instance has only very recently come under my notice of the way in which good old art relics are destroyed. In Parker's Glossary will be found an illustration of a fine old chest, at Guesting Church, Sussex. A friend of mine, in making a tour through the country recently, was curious to see this chest, but after a long search, the only part he found remaining was one of the panels; all the rest had been cut off, probably to be used in the building of a new house. With reference to the constructive treatment of wrought ironwork, the greatest evil of modern gothic work is the alarming extent to which the practice of screwing and rivetting together of the parts is carried, instead of adopting, where possible, the more lasting and workmanlike process of welding. Screw is a process which ought never to be adopted, for it not only does it give a brummagem and toyslop character to the work, but offers a great temptation to the mischievously inclined to attempt the dislocation of the parts. Of course there are methods by which the drawing out of the screws can be prevented, but it is a bungling affair after all, and it is lucky for us that it is not a fad, and it is not. If the old smiths, or their works would not have been handed down to us in so complete a condition as we now see them. It is this screwing on ad infinitum of leaves and rosettes, all having the appearance of having been punched out of a thin sheet of metal, which gives the machine-made look before referred to. Rivetting ought only to be resorted to when welding is not possible, but even then, in many cases, bands or collars welded round the parts to be attached, as in old work, would be the strongest method, and the most preferable with regard to appearance. An example of an injudicious arrangement of rivets may be seen in the wrought iron area raling to the houses of the Archbishop of Canterbury. Wrought iron work, the scroll have been twisted out of their places, from being fixed so that they could turn upon the rivets. To ensure excellence as well as durability in wrought iron work, the hammer ought to be the master-tool, and the shears and file used as little as possible. As a general rule, old methods of construction are not always to be followed as the best, as they are often careful in many respects, as may be seen occasionally in the forging of timber or the binding of stonework. Although the indiscriminate use of cast iron has been one of the curses of modern architecture, and there is more interest attaching to the smallest scrap of wrought iron, than to the tons of the most celebrated and known, there are many positions in which it may be used with advantage, but above all things, it ought to have a character entirely distinct from that of wrought iron, whereas the latter ought to be stiffer in waving lines, cast iron ought to be stiff and geometrical in its forms, and should either be used in positions where it is not likely to meet with rough usage, or where the dimensions of the objects are such as to preclude the possibility of their being
fractured, accidentally or otherwise, such as the columns for supporting warehouse floors or roofs, or street lamp-posts of appropriate design. We all know the effect of one of our street lamp-posts of the present period being struck by the wheel of a passing carriage, which always fractures it at the weakest point, which is most ingeniously placed in the best possible position for the purpose. There is therefore a feeling that in forming our ideas as to how our ironworks are to afford an excellent opportunity for effective designs in ironwork, from their being generally seen against the sky. When cast iron is employed at all, the metal ought to be of the best description, and the castings ought to be as perfect as possible, and not require any filing up or tinkering afterwards, and to ensure the result being reached at all, and finding its way to the maker, it ought to be drawn out to the full size of the pattern and not to that of the finished casting, as, if made to the size of the latter, the pattern maker will have to make the enlarged drawing to allow of the proper amount of shrinkage of the casting in cooling. Regard must also be had to the equalization as much as possible of the sectional area of the various parts of the design, so as to guard against the possibility of fracture from unequal cooling. More than ordinary care, instead of less, as is the almost universal rule, ought to be bestowed upon the designs for cast work of any description which has to bear a number of repetitions. Geologists say the museum contains every wonderful example of fine sand casting in iron from Magdeburg in Prussia, in the shape of ladies' fans and jewellery. In England, the Coalbrookdale Company have always been celebrated for their fine castings, but the art treatment of their works, as well as those of the other large founders, would admit of so much more refinement. The beautiful and magnificent variety of geometrical and arabesque designs, to be met with in the metal work of the Indians and the Arabs, would furnish quite a new field for study in the improvement of cast iron work, and ideas might be obtained for light cast iron grilles for windows from the elaborate carved stone screens of Northern India, which were exhibited in Kere exhibits in London in 1851, and of some of which are now to be seen in the India Museum. A matter of minor importance in relation to ironwork, but which affects to a certain extent its durability, is its insertion into stonework. The disadvantages of lead for this purpose are well known. Sulphur and Portland cement have been used with some success, but the danger of the metal work being thrown from the oxidization of the metal caused by damp. As cast iron is known not to be so susceptible to this influence as wrought iron, it might be used for the standards for wrought iron work, by placing them at convenient distances, and making them of a sufficiently massive character. Cast iron is being used for this purpose in France, and in France inverts and inverted pipe-stoppers stuck into the bed of a river, was a perfect disgrace to the corporation, and he considered that some representations ought to be made to the company on the subject. It was, of course, too late to prevent the damage, for the company were now engaged in adapting their designs to something which was not quite so capable of being altered as the iron used in making these ornamental ironwork designs. The question of colouring ironwork is an important one, and deserves notice. I cannot say that I sympathize with the barber's-pole style of colouring so fashionable for ecclesiastical metal work, which probably is found to be attractive to the clerical eye. A better effect might certainly be obtained in most cases of inlaid iron, and the reason that old ironwork is alone, properly selected, and heightened if you like the use of gilding in prominent parts. Ironwork ought to depend for its effect mainly on the beauty of its forms and curves, and should not have the outlines distorted by colour applied without any meaning, as if the colourist had attempted to crowd the greatest possible amount of ornamental detail into the space. Colouring ironwork, the back ground ought to be the guide for the predominant colour, which ought to contrast favourably with it, and as a rule, to ensure a good effect, the ironwork ought to be darker than the background, never lighter, unless it be wholly gilt, which has a good effect, if the design is of a very light and open character, as in the gallery railings to the reading room of the British Museum. The beautiful wrought ironwork to the choir of Notre Dame at Paris, designed by Viollet-le-Duc, has been entirely gilt, but being of a very elaborate character, the effect is not good. I am not aware of any electrotyping with copper and bronze has yet been introduced into England for the purpose of protecting ironwork from rust, although this process is much used in France. An excellent mode of preserving iron from rust is to galvanize it previously to painting, but it is found that iron of the best kind and closest texture does not oxidise to anything like the extent that wrought iron does, in which a comparatively perfect state is, that greater care was taken in the preparation of what we may call the raw material, which was worked up by hand, and not sent wholesale through rolling mills. It will generally be found that where machinery is allowed to intrude into the domain of art, an increase of quantity may be the result, but never of quality. It is instructive to notice by what simple and trifling means a truly artistic effect was obtained in early ironwork, and we are thus taught the lesson that a little care and a little trouble towards its maker can result in a greater improvement, with the hope that they may conduce to the furtherance of this desirable object, so that every scrap of ironwork may have some interest attaching to it, as of yore, and there will then be some chance of our rivaling, if not excelling, the genuine work of the mighty men of old.

Mr. Ridge remarked that Mr. Lewes had shown that the manufacture of good ironwork was not confined to the medieval period, and he believed that cast iron was still made in London at the present time, though the designs differed at different periods, the principles of all good work remained the same. The museum at Rouen referred to by Mr. Lewes, was most valuable as a study of all kinds of cast iron, as it had nearly always been its misfortune to be designated as an imitation of some other material, it was therefore most important that architects should be able to give it a character proper to itself. Cast iron capitals designed both by the India Office and by engineers' work, artistically considered, was generally simply horrible, so that a wide field would open to architects if they would make ironwork artistic. It was not of course difficult to imitate what had been accomplished by artists of preceding times, such as metal screens and works of that class which used to adorn the palaces of London at the present age required. Transverse iron girder girders had not a bad effect, but they were generally spoilt in our bridges by the kind of sentry box put over the piers, to cover the junctions of the girders. He concluded by expressing a vote of thanks to Mr. Lewes for his paper.

Mr. Dunphy said he quite agreed with Mr. Lewes in deprecating the abominable manner in which the London and South-Eastern Railway Company had contrived to carry their railway across the Thames at Charing Cross. The iron bridge put up there, with its ugly pillars, and inverted pipe-stoppers stuck into the bed of a river, was a perfect disgrace to the metropolis, and he considered that some representations ought to be made to the company on the subject. It was, of course, too late to prevent the damage, for the company were now engaged in adapting their designs to something which was not quite so capable of being altered as the iron used in making these ornamental ironwork designs. He believed that cast iron work designs could be best obtained either by enclosing floriated patterns within definite bounding lines, or by the frequent use of spiral curves.

Mr. Dunphy inquired if Mr. Lewes could account for the excessive prices charged for any ironwork of superior design. Mr. Lewes replied that this was a question in which, if an architect wanted work according to his own design, he must pay extra for having it executed. Common articles which were kept in stock were of moderate prices, while original designs were rendered more expensive by the extra labor.

Mr. Ash observed that architects of the present day were too fond of copying continental ironwork, in which the screw and rivet were used because if the work were welded at the joints it caused additional labour. With regard to the appearance of ironwork in England he stated that much good old ironwork had been destroyed during the last twelve years. During the repairs and restorations of churches the old ironwork, however beautiful in design, was too often destroyed, which was much to be deplored. The President, in voting the thanks of the meeting, said the
Association was much indebted to Mr. Lewes for the manner in which he had brought a very able paper before the meeting. Referring to what had been said as to the difficulty of obtaining good examples of ironwork, he instanced the screen at Westminster, and the gates at Merton College, Oxford, as being specimens worthy of study. A vast amount of the ironwork of which Mr. Lewes had spoken still remained, though much had been destroyed. He advised that all architects should take care that no ironwork of any kind, having any merit as to design, should be destroyed. In rebuilding or altering any building, the architect should try to preserve it, as he did all old work in a church restoration. He could not imagine any architect of the present day designing the patterns which appeared in the manufacturers' books; but if architects were told they would find the work would be seventy-five per cent. cheaper if they took some of the manufacturers' designs, there would be no wonder if they submitted to the force of circumstances. The fault was with the manufacturers, and he was sure they might manufacture good designs as cheaply as the present very inferior patterns. On one occasion he had asked a manufacturer in Thames-street why he allowed such designs to appear in his pattern books? And that gentleman's reply was, "the fact is this, if one architect designs a good thing, somebody else comes in and tells me it is horrible, and between the conflicting tastes of professional men, I am quite at a loss to know whose opinions to follow." He thought that architects should treat ironwork as they treated any other part of their building, and if it cost more to have it in good taste, then it should be in the estimate. He objected to students studying the works of any modern designer in ironwork being told that they should look altogether to the teaching of ancient examples; they should not follow one architect more than another, but work to the best of their ability and knowledge.

The vote of thanks to Mr. Lewes was carried unanimously. The following were returned as the officers appointed for the ensuing year: President, Mr. Robert W. Dis; Vice-Presidents, Messrs. R. Phenix Spiers and Edward J. Tavener; Committee, Messrs. G. H. Birch, J. S. Edmeston, E. B. Ferrey, H. L. Florence, Ernest Lee, C. F. Lewes, W. Lonsdale, J. S. Quiller-Couch, W. G. B. Trevelyan, Mr. J. Douglass Mathews; Hon. Solicitor, Mr. Francis Truefitt; Auditors, Messrs. C. B. Arding and J. A. Bunker; Secretaries and Librarians, Messrs. L. C. Riddett and W. Frewe; Hon. Secretaries, Messrs. J. Douglass Mathews and Rowland Plume; Registrar and Collector, Mr. William Farthing.

Rebiew.


Concluding Notice.*

We regret that in several of the views given of steam fire engines, so little is shown in the way of detail or even of the actual external working parts of the engines as constructed. We may instance especially the view of Messrs. Shand, Mason & Co.'s. horizontal engine of 1868, and that of the patent vertical engine of the same makers, also dated 1868, both of which strike us as being deficient in many particulars which we have been accustomed to associate with the engines purporting to be represented. It is easy to understand that these parts may have been omitted for the purpose of avoiding complexity in the figures, but we believe that a omission much of the value of the figures is lost, as they fail to give the thorough idea of the machine, which it should evidently be their object to produce. As regards the boilers of these engines, of which we should have liked to have seen sections, we presume that the accompanying figure and description taken, as we are informed, from the specification of Mr. James Shand's patent of 1865, will sufficiently give the type. The accompanying engraving (Fig. 7) is a longitudinal section, showing the construction of the boiler, steam engine, and pump. The fire box A is of conical form, so as to give ample space for grate or furnace. The fire box communicates with the smoke box B and the chimney by the vertical tubes C. In order to diminish the water space and increase the steam space, two semi-circular metal cases or pockets D are fitted with the boiler round the space occupied by the tubes C. The casing D communicates with the steam space by two or more open pipes E, which ascend above the water level, and small cocks (not shown in the drawing) are fitted in the bottoms of the cases D through the sides of the boiler, to draw off any water that may be formed by condensation. The upper shell of the boiler can be taken off by means of the bolted joints F and G; and the top of the smoke box can be taken off to repair the tubes, &c., by unscrewing the joint at H. The engine is composed of an inverted steam cylinder I, placed above and concentric with a pump K, which parts are framed together by the four bars L, which connect the enlarged head of the pump with the cylinder bottom, and which frame I also carries the bearings for the crank shaft M. The pump is fitted with India-rubber discs, which form the foot valve. In action, the suction is drawn in the up stroke by the bucket O, and in the down stroke about half the water is discharged by the displacement of the plunger N, and at the next up stroke the remainder of the water is discharged by the ascent of the bucket. The enlarged head of the pump X is fitted with a large air vessel Q, and nozzles to take the hose at R. Over the openings to these nozzles at S is fitted a valve, shown in plan in the engraving, which is so constructed as to admit of both outlet passages being open or to close either at pleasure, but not to close both outlet passages at the same time. The connecting rod T is jointed to the bottom of the pump plunger W, which is itself attached to the steam piston by two piston rods, between which the crank works. Upon one end of the crank shaft X is keyed a fly-wheel, and upon the other end an eccentric, which works the slide valve and the feed pump Y. The governor is constructed with a piston fitted into a cylinder, with a trunk and stuffing box; the connecting link from the piston is attached to the lever of the regulator, a pipe is connected with the steam jacket of the cylinder, and another pipe with the enlarged head of the main pump, so that any change in the pressure of the water in the pump will cause the piston of the governor to be moved by the pressure of the steam, and thus regulate the admission of steam to the steam cylinder of the engine. Boilers of the kind represented possess, while new and clean, most excellent steam properties, and at first sight seem admirably adapted for steam fire engine purposes, but when

* See note, pp. 189 and 311.

FIG. 7.—LONGITUDINAL SECTION OF SHAND, MASON & Co.'S. VERTICAL ENGINE.

59
further examined we think it will be clear that the objections to them, as compared with some of different construction, considerably outweigh the advantages. Thus it would appear to us, that in the first place, they must be necessary be expensive to construct, and from their formation not entirely free from danger of explosion, while at the same time the unequal expansion of the parts will be likely to cause continual annoyance by leakage. The tubes, too, we should imagine must quickly become coated with deposit so as to greatly lessen their power of conducting heat to the water. Such at least is found to be the case with locomotive and marine boilers fitted with similar flue tubes passing through the water space. These are points which we think are well worthy the consideration of the makers.

The form of engine shown being of the quick running short stroke class, must, we fear, be somewhat unsteady in its action and liable to frequent derangement. It has always been our opinion that long steady strokes, with direct action between steam cylinders and pumps, are much to be preferred to those in which not only is the stroke short and rapid, but the motion, after having been converted from rectilinear into rotary, has again to be converted from the rotary of the fly wheel shaft into rectilinear in the pumps. The more direct the action of the parts and the fewer their number, consistent with the proper action of the machine, the better, and we think that this principle properly understood and carried out would go far to prevent the recurrence of circumstances, such as that alluded to by Lord Naas, who, according to a report in the Standard of the 13th of June, speaking of the late fire at Dublin, said it was stated "that the steam fire engine, which arrived a considerable time after the outbreak of the fire, fell completely to pieces." It is no doubt an exaggeration to say that the engine referred to "fell completely to pieces," but that it became completely divided is far from improbable, and would be a circumstance certainly not of very unusual occurrence.

That mishaps can at all times be avoided, even with the best constructed and most simple engines, we do not for a moment assume, but that many break-downs are clearly traceable to the engines being decidedly wanting in these particulars is certain;

FIG. 8.—MERRYWEATHER'S CHAMPION ENGINE, "Sutherland," 1863.

and we, in common we think with engineers in general, should have been glad if Mr. Young had entered at greater length into the subject of constructive detail and the principles upon which it should be carried out. In this way and by analytical comparison of the several engines whereby known results have been achieved, and which have steadily maintained their efficiency during lengthened periods of service, we think that much good might have been done, although at the same time it must be admitted that to do this in a thoroughly efficient and reliable manner, giving not only the aggregate of work done by, but the cost of maintenance of each engine and the fuel it consumed, would be a matter of great difficulty, if indeed it could be achieved at all. Further than this, we must not lose sight of the fact that Mr. Young's work is evidently rather a popular history and resume of the whole subject of fires and their prevention, than one intended for the use of engineers, or of any other class of the public exclusively. In this point of view and as calling attention to past facts, past, and we may add, still existing, prejudices and exclusiveness, it may be of great service, and lead to the avoidance in respect of fire engines of an error comparatively as grievous as that of the Austrians in respect of improved firearms. The fact is that in these times progress is a necessity which will assert itself, and happy will it be for us as a nation, if we thoroughly realize this truth before being reminded of it, by loss either of commercial or political position. The Americans seem to be peculiarly alive to this, and to understand that it is better to run the risk of sometimes making a blunder, than to continue bound in the trammels of red tape or prejudice. It is unfortunate that not even facts themselves are at all times sufficient to ensure a just sentence, and hence we find that many inferior things are patronized, where others which are far superior are comparatively unknown. Still it is evident that tables of results, such as those so carefully given in this work, must lead to reflection, and we should hope, in the end, to a general adoption of the most correct principle, which, it will be observed, is in the direction we have already more than once indicated, and which is evidently the one which Mr. Young's observations lead him to prefer. Of the Sutherland, which is an admirable example of the class of direct acting engine to which we have referred, Mr. Young quotes the following from the last report of the late Lambeth Fire Brigade, which, referring to the Crystal Palace trials, says, "The Sutherland (Merryweather and Sons).—This engine worked most satisfactorily throughout the whole of the trials it was sub.
jected to: its jets were quite free from pulsation, and its water and steam pressures were very equal; the water in the boiler was also very regular in quantity. The water cylinder, through a defective casting, leaked slightly during the first day’s trial, which prevented the engine from accomplishing greater results, but it was repaired in the course of a few hours. The pumps were not charged for any trial, and the boiler did not prime in the least."

As regards the construction of the first steam fire engine in America, Mr. Young says, "The honour of having constructed the first steam fire engine in the United States has long been given to Mr. John Ericsson, and it has generally been believed, at least in this country, that to him the credit of this was due. Great pains and a considerable amount of research have satisfactorily proved, however, that this is not the case; but the grounds on which the idea became established were, that in the year 1840 he obtained the gold medal which was offered by the Mechanics’ Institute of New York for the best plan of a steam fire engine."

"A design for a steam fire engine was sent in by him in answer to the offer, and this engine being almost identical, except in the boiler, with those which had been so successfully manufactured and employed by Mr. John Braithwaite in London some ten or twelve years before, and consequently, had been pretty well proved in working, naturally carried off the prize, as there could be little room to doubt its being successful if carried into practice."

"No account has been found of its ever having been made, nor has any information been received in answer to the inquiries made respecting it. The following remarks, and the sources whence they were obtained, seem evidently to show that they added in no small degree to the propagation of this idea:—In Le Cuns’ work, ‘The United States and the Canadas,’ written in 1841, it is stated that one of Ericsson’s engines was then being built. It was to be a little over two tons in weight, and to throw 3,000 lbs. of water per minute, equal to about 100 gallons per minute, to a height of 100 feet, and so arranged as to throw four streams at once if required."

"The Mechanics’ Magazine, for 1840, contains the following extract from the Times respecting this engine:—‘A steam fire engine has been invented at New York by Capt. Ericsson. It weighs only 2½ tons, and will throw 3,000 lbs. of water per minute to a height of 100 feet through a nozzle of ½ inches in diameter.‘"

"The first steam fire engine constructed in the United States was designed and built by Mr. Paul Rapsley Hodge. C.E., a well known English engineer, at his own works in New York, in the year 1840-1. It was a self-propelled engine, the first of the kind ever constructed, with horizontal cylinders and pumps; a locomotive boiler, in some respects like the style introduced by E. Bury for locomotives; the slab or plate framing to which the cylinders and pumps were attached, as is now used in locomotives; and wrought iron wheels, which were manufactured by the Matteawan Company for Mr. Hodge. It was arranged to be drawn by horses if required, as well as by hand and its own steam power; and this, about twelve years after steam fire engines had been in use in England, was the first made and used in America."

We give the figure of Mr. Hodge’s engine, which appears to have worked in a most satisfactory manner, giving results, which will compare very favourably with others of much later date; we also give an engine as constructed by Messrs. Poole and Hunt, of Baltimore, in 1865, of which we are told ‘the pumps employed by Messrs. Poole and Hunt are of a peculiar character, consisting of two barrels placed one over the other, in each of which are two pistons, attached to each piston rod, and fitted with india-rubber valves. The two piston rods are attached to a cross head, which is again attached to the piston rod, so that one cylinder and steam piston works the two pumps, and the four pistons connected with them, a small fly-wheel being used. They are constructed of three sizes or classes, each of the following weight:—No. 1 = 6,500 lbs, or 2 tons 18 cwt. 4 lbs. English; No. 2 = 5,000 lbs., or 2 tons 10 cwt. English; No. 3 = 4,500 lbs. or 2 tons 20 lbs. English. It is found that the second class is of sufficient capacity for use in the largest cities, whilst for towns or cities of moderate size, the third class is ample." The trials at Rotterdam between an engine made by Messrs. Shand, Mason and Co., and the engine, “De Maas,” by Messrs. Merryweather and Sons, are given from the official report of M. Von der Tak, Director of the Board of Works there. This report is accompanied by a diagram, showing the forms, heights, and horizontal distances of the jets thrown by each engine, of which a copy is given, and which is remarkable as showing the superior steadiness and continuity of the jets thrown by the longer and slower stroke of engine. There is, however, another class of engine of which we have as yet but little practical knowledge in this country, namely, that of which the unfortunate “Manhattan” is the type. Of the arrival of this engine to take part in the Crystal Palace trials, our Author says:—"The Manhattan, and the delegation, in the hands of the London Fire Engine Establishment, arrived at the Crystal Palace on the 30th June, and the engine having been weighed and the boiler tested, was declared all right, and was then to be removed to the portion of the grounds set apart for the trial. Instead of the engine being taken by the easiest and nearest way to this point, it was taken round by the north tower, where there was a steep incline; but when it reached the top of the incline, and began to descend, the weight overpowered the men in charge of it, and the man of the London Fire Engine Establishment, who had hold of the pole, was unable to guide it, and it ran away down the incline, and, at a point where the road curved, ran into a tree and capsized, smashing the engine and severely injuring the fireman before alluded to."
"The force of the blow knocked off the fore-carriage, broke one of the flywheels, and cracked the other, turning the engine completely upside down, thus leaving the engine, the night before the trials, in a most crippled condition. The delegation who brought the engine over, however, would not be beaten; and, procuring the assistance of some labourers, set to, to try and get the engine into condition for the next day’s trial. By dint of great exertions they succeeded in doing so, so far as to have it on the ground in time, and thus prevent loosing the entrance fee. At this stage of the proceedings it was objected that the accident might have caused the engine to have become dangerous and unsafe to work, and therefore it ought not to be tried at all; however, after much discussion, it was resolved to prove the boiler, and accordingly, with a laudable desire to prevent injury to the public, and which has been shown on numerous other occasions, the superintendent of the London Fire Engine Establishment proceeded to test the boiler with a water pressure of 250 lbs. on the inch, and double the pressure required; but the engine injured as it was stood the test well."

This mishap, and the culpable mismanagement, which led to it, are greatly to be regretted, not only because of the loss of the opportunity for testing that particular construction of engine, but on account of the feeling it induced on the part of our American brethren, that a desire existed to do them less than justice in this country. We trust, however, that this feeling will subside when it is seen that all among us whose opinion is of value are prepared and anxious to give American inventions as full and fair a trial as is accorded to those of our own countrymen, and whether the competitor be a Manhattan or a Miantonomah, we are prepared to accord to it the fullest measure of praise or acknowledgement of superiority its performance may deserve. Upon this subject, we regret to find the Authors’ experience leads him to speak as follows:—"So far as the Author can gather from Americans resident in London, the disgust and annoyance felt by them from the treatment they received on the visit of the American firemen and engines in 1863, and the results of the so-called ‘trials’ have raised such a feeling amongst them as cannot fail to lead them to refuse any information, or to render any assistance on such a subject, when sought to be obtained from this side of the Atlantic."

We cannot enter at length into a discussion of all the features of Mr. Young’s work, which touches upon almost every detail of fire and their prevention, showing not only what has been done in our own country but in the other parts of the world, and giving numerous suggestions which can only have arisen from a careful consideration of the subject and a sincere desire to advance the ends of truth. To all those who may feel an interest in a subject of such importance to us all, we cannot do better than recommend an attentive perusal of this laborious work, which we feel assured will direct attention to many points of importance not hitherto either properly understood or fairly appreciated.

BUDDONNESS LIGHTHOUSES, RIVER TAY.

The apparatus employed in the towers of the two new leading lights at Buddonness, consists entirely of glass, and is somewhat curious and intricate in its details. It was constructed from the designs of Messrs. Stevenson by Messrs. Chance of Birmingham, and is remarkable and unique from its combining every kind of dioptric lighthouse apparatus. The whole of the light which comes from the burner is condensed by the best optical agents (no metallic reflection being used) into a horizontal arc of forty-five degrees, and spread over that area equally by means of the following instruments, viz.:—Fresnel’s fixed light apparatus and annular lens; also the following instruments of Mr. Thomas Stevenson—the azimuthal condensing prisms, heliophote, right-angled conoidal prisms, and dioptric spherical mirror, with Mr. J. T. Chance’s setting. The conoidal prisms have never been employed before. The azimuthal condensing prisms were first used at Isle Ornsay Lighthouse, Argyshire, in 1857, and the dioptric spherical mirror was first introduced by Messrs. Stevenson into a lighthouse in the colony of Otago, but it has not been applied till now in any light in Britain. It is composed of glass prisms, and possesses the property of returning all the light that falls on it back again to the flame, so as to increase its effect without allowing any rays to pass through, but causing all to go seawards. Hence an observer standing behind the apparatus sees no light, although the screen between his eye and the flame consists only of transparent glass prisms.

The Board of Trade have lately given authority to the Commissioners of Northern Lighthouses to get a facsimile of the Buddonness apparatus constructed for being shown at the Paris Exhibition. The lights were permanently exhibited on the 14th July, 1866.
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

ON THE ARCHITECTURAL HISTORY OF THE COLLEGE AT ETON.*

By Professor Willis.

The Professor prefaced his account with some introductory remarks on the general history of colleges and their growth. The universities were at first corporations of educated men, the teachers or doctors in which instructed by lectures in the public schools, the students being obliged to find lodgings for themselves. Soon, however, generous persons gave funds to assist poor students. After a time a more definite shape was assumed by these institutions, and it was provided, that the morals and manners of these students might be brought under superintendence and control. The next step was to purchase houses, endow them and provide them with statutes. Thus arose the communities termed colleges, residing in buildings called the Domus or Aula, which at first contained little else than chambers to lodge in, with a dining-hall, kitchens, &c., like the ordinary dwelling-house of the period. The first of these colleges was that at Oxford, by Walter de Merton, in 1264; one was founded at Cambridge soon after; and others followed at intervals up to 1579, when in the so-called New College at Oxford William de Wykeham founded the first architectural building, and, as it is in all such cases, and so well organized in its statutes, as well as in its structures, as to serve as a basis for all subsequent erections. His plans also included the then new feature of a preparatory school, at Winchester, for young boys, from whom the members of his Oxford College were to be selected. The Professor next proceeded to the consideration of King's College, Cambridge, and its appendage Eton. He gave a touching account of the effect of the misfortunes of Henry the Sixth in retarding and finally suspending these works, followed by a just parallel between the continual devising of plans for the education and elevation of his people by that monarch, into a constant effort by the same by the late Prince Consort. Prof. Willis then detailed the original plans for Eton College as set forth in that monarch's "will"—this will be, however, not a "last will and testament," but in reality a building specification for his colleges, in so far as it contains that outline only on the map. It shows in beautiful illustrations the arrangement of the grounds, the buildings, and the school, and also the result of such plans. Henry, however, did not mature his plans at once, but modified them very considerably at a short subsequent period. He first founded a collegiate criminal-school at Eton, and a small college at Cambridge, dedicated to St. Nicholas, that saint's day having been his birthday. A site was purchased at Eton, north of the cemetery of the old parish church (now no more), and the King came down and laid the first stone, over which was to be the high altar of the new collegiate church. The King soon enlarged his plans, increasing the number of his benefactors and connecting, by statutes copied from Wykeham's, Eton School with King's College at Cambridge.

The contemporary building accounts and documents, containing the King's projects and instructions, long mislaid, and believed to have been stolen, were, by a fortunate discovery discovered in a forgotten recess of the Library at Eton, about two months since, and liberally submitted to the Professor's inspection. They contain abundant proofs of the personal interest which the King took in the details of the college buildings, and of changes and improvements introduced by him as time went on. They show that the works at Eton were of two kinds, carried on simultaneously. First, the enlarging, refitting, and altering of buildings that already stood on the site purchased by the King, including the parish church, of which he obtained the advowson, and its conversion into a collegiate church. These buildings were so treated as to make them serve as temporary dwellings for the accommodation of the provost, fellows, and students and of the hospital, which was intended to be brought into active existence from the beginning, without waiting for the erection of the magnificent architectural pile described in his will and other documents, and which was commenced simultaneously with these temporary operations; but which, even if carried on in prosperous times, would necessarily have occupied many years in completion. The chancel of the old parish church was rebuilt on a larger scale, and fitted with stalls and canopies for the daily choral service. A hall in one of the old houses was enlarged; a school-room and other buildings constructed of wood. The almshouse for poor men, described in the will, was also built.

The permanent College was also begun; the first buildings attacked being the great chapel, which was erected, and the bell and other chapels. This chapel was placed in the old parish churchyard, to the north of the old parish church, and was planned as the chancel of a large collegiate church, to be provided with a nave or body for the parishioners, as described in the well-known will of Henry the Sixth, dated 1448. But, after the signature of this will, the King was enlarged and other buildings. He sent persons to Sarum and Wotton, and other parts, to measure the choirs and naves of churches there, and had improved designs made for the college buildings.

The Professor found among the documents two specifications relating to the chapel, the one exactly corresponding to that of the will, but in which every dimension is struck through with a pen, and an increased dimension written above it. The other specification describes the chapel or church, as it is called, in different phraseology from that of the will, and more completely. The dimensions in this latter paper are still greater than those of the corrected document, and, what is more curious still, they correspond exactly with the model he erected and built the work on, the remaining minute directions that the foundations of the chapel, which had already been laid (of course in accordance with the will, for the works had been in progress for seven years before that will was signed), should not be disturbed, but the new foundations (i.e. for the enlarged dimensions), be laid round the outside of them, and be constructed with the greatest care, and with "mighty mortar." The first stone under the high altar to remain undisturbed. This stone was protected by a small chapel built over it in the first years of the works.

The deposition of the King, in 1461, put an abrupt stop to the buildings, which had languished during his increasing misfortunes. It is said that they were never touched again, or at least that the work was stopped at a long interval of time. By his confidential friend and executor Bishop Waynflete, is stated by Leland, and also shown by an indenture, in 1475, between him and a carver, who engaged to make a rood loft and stalls for the new chapel, and to take down the rood loft and stalls in the choir of the old parish church. This proves that the new chapel was only brought into a condition to receive its fittings. It must have been just roofed in. The Professor pointed out to his audience evidences of the haste in which the upper part of the chapel had been completed. The arch heads of the windows are abruptly depressed, in a way which shows that the walls of the chapel were intended to have been much higher, and that the recesses of the wall and springing of the window-arches. It is probable that the work had been carried up exactly to this level when the death of the King stopped the operations. When resumed by Waynflete, with insufficient funds, expedients were adopted to enable the buildings to be rapidly finished and roofed-in for use. The hall exhibits similar evidences to show that its walls and windows were designed to have been carried up to a much greater elevation than they now present; and that after a sudden interruption it had been hastily put into a condition to receive the roof, which is of a very plain construction. The magnificent body of the collegiate church designed by the founder was never even commenced, the choir, or portion of the chapel, being terminated westward by a low篇章 ante-chapel of slight construction, probably the work of Waynflete.

The old parish church appears to have been pulled down after the present chapel was prepared for service, as above stated. The parishioners retained the right of employing this chapel as their church. But that church is not the church of the students and of the population, and other causes, creating great inconvenience, both to the college and the parish, a new church or chapel-of-ease was erected in the town of Eton for the use of the parishioners.

The arrangement of the college buildings differs entirely from that described in the will of the founder in 1448. The Professor concluded from this, and from the mention of a plan or "Portrautra" exhibited to the King, in the following year, "for the finishing of the buildings of the college," that he, when adopting an enlarged design for the chapel, had also determined upon a new disposition for the other buildings.*

* Abstract of Address before the London Congress of the Archæological Institute.
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

The college in the will is imitated from Wykeham's colleges, consisting of a quadrangle, containing hall, library, and chambers, and of a cloister. But in the existing college the quadrangle of chambers contains not only the hall and library, but is also cloistered. The site of the cloister first proposed, but never commenced, is that now occupied by the school-yard. The cloister is arranged upon a plan unusual in colleges. It was built in two stories, having chambers on the north and east sides, and the hall on the south, the dimensions of which agree exactly with the founder's will. The upper chambers are not reached in the usual manner, by assigning one staircase to each contiguous pair; but a gallery is carried round the upper floor, exactly as the cloister of the Bodleian overlooks the garden, and gives access to the doors of the chambers. At each internal angle of the quadrangle, or quadrant, as the will terms it, is a square turret containing a spiral stone stair, or vice, with a door below and above, by which the upper gallery is conveniently reached.

The chamber buildings were carried round the east and north sides in one style, and probably in the founder's time; but the west side, which contains the great gateway called Lupton Tower, was built, after a considerable pause in the works, in a totally different manner during the provostship of Lupton, and probably in the reign of Henry the Eighth.

The cloister-arcade and chamber-doors on the ground floor on this side the arcades, however, to the earlier building, and to have been suddenly stopped in an unfinished state. This western side of the quadrant is wholly devoted to the provost, and contains a large dining-hall, termed "Election Hall," with a withdrawing-room behind it, over Lupton's entrance-arch, and large bedchambers beyond, joining the hall. In the will of the founder a master chamber was made for the reader to this position in two stories. The present extension is accounted for by the bountiful hospitality which, and after the period of Henry the Eighth, was exercised by the masters of colleges in favour of the nobility and gentry. This compelled the building of chambers and reception rooms. After the Reformation the masters of colleges created a new demand for space, and made it necessary to supply these officers with a family residence.

The subsequent works carried out in this college were enumerated as follows: The lower school, or north side of the entire quadrangle, or school-yard, was built before 1581, and has the long dormitory above it. The library in the cloister quadrangle was built by Sir Christopher Wren. The new upper school, which is the western boundary of the school-yard, was rebuilt in 1899. In 1758 an attic was raised upon the east and north sides of the cloister court, and the entire group of chambers altered so as to convert them into a row of private houses of the fashionable sort for the fellows of the college. Lastly, the interior of the chapel, which had been refitted and "beautified" in the Italian style in 1599, by Mr. Banks, was well restored to its ancient aspect, with rich stalls and canopies, in 1860, from the designs of Mr. Deacon.

THE ARCHITECTURE OF ASIA.

Since the revival of Medieval architecture, the studies and researches of archaeologists and professors have been usually limited to Europe. We began—and very naturally—with that phase of our own English Pointed which approached nearest to our own day in point of date, and which is connected with the Italian work of our best Renaissance period by the transitional English Lancet.

From Perpendicular we fall back successively on Florid Decorated, Early Decorated, Early Pointed, and Norman; and then we began to have recourse to French examples, taking them also in the same retrograde order, till French Romanesque was nearly exhausted by the archaeologists—though not as yet by the critics, the leading men of the early Christian architecture of Syria and Asia Minor; and before long we shall have doubt hear of Early Syrian as an admitted style in which to erect a nineteenth century church.

Some portions of this field of art available in Europe have been more popular than others, but magnificent examples of architectural research exist, from which the Moorish architecture of Spain, the Norman of Sicily, the still earlier art of Ravenna, and the more oriental types of Venice, have respectively furnished the subjects, although notwithstanding that there is not one of these phases of art which can ever be said to have been popular enough here or in France for its revival to have been seriously attempted.

It will soon be time for the antiquarians, whose cry like that of the ancient Athenians, is ever for some new thing, which, however noble, must be old in their eyes, and turn their attention to a new field; but it is also not improbable that among the students of architecture, as distinct from archaeology, there are few who will not welcome an introduction to a fresh field where a development of architectural art hitherto little known or valued awaits their study.

To the west India may be well recommended as containing a fund of wealth, little known, and less cared for, embodied in piles of masonry crumbling to decay, and fast becoming deserted and destroyed, but displaying a noble, a consistent, and a highly developed phase of art.

We have before us at this moment a volume of photographs from some of the most remarkable Mohammedan buildings of Ahmedabad, of which we shall in a future number give a careful notice, in the form of a review. This, by far the most accessible illustration of the art to which we are now endeavouring to speak attention, shows a mere fragment of the whole, and gives but an inadequate idea of the beauty and completeness of the work. Such as it is, however, we are delighted that it should be published, for the periods of high art have not lasted so long and their influence has not extended so wide as to make us willing to forgo the knowledge of any truly noble work; and however well such works as these of Mr. Ferguson may have unfolded some of the peculiarities of the various Indian styles, the beauties of this, by far the most artistic of them all, are not familiar to many. The distance and climate of India render a visit to these works themselves formidable, yet we cannot forbear expressing the opinion, that before long they are likely to become a favourite field of research.

COTTAGES FOR AGRICULTURAL LABOURERS AND WORKMEN.

(With an Engraving.)

So much has been said and written upon this subject during the last few years, that it might appear little more relating to it remains to be stated or suggested. A variety of designs for cottages have been illustrated and described from time to time in the Journal, and the number of these have possessed considerable merit, as to design and arrangement of plan. In many counties of England examples of such cottages have been erected, and are proofs of the great desire on the part of some landed proprietors to benefit the agriculturists living upon their estates. In other cases, large manufacturers have manifested a great interest in the welfare of their workmen by the erection of whole villages of improved dwellings, the rental from which would not return even a moderate interest upon their cost. Those landlords who have in this way studied the comfort and well-being of their labourers appear to have adopted the late Lord Palmerston's idea who considered it was the duty of the landlord to provide decent homes for the agricultural labourers working upon his estates. He felt justly, that the wages received by the labourer is such that it is out of his power to pay in weekly rent sufficient to render cottage building a profitable investment; but he considered that a farmstead is imperfect unless the landlord provide cottages for the labourer as a necessary appendage to a farm, in the same manner as a dairy is to a farm house. As such he placed the investment on the acreage of the land.

The model cottages built by the late Lord Palmerston at Broadlands, and by other landlords, do them much credit, but a mistake has in most instances been the unnecessary cost of the work by making the rooms larger, with walls finished inside more expensively, than is at all desired by an agricultural labourer, thus causing these improved cottages to be comparatively rare in England.

Landlords desiring to erect labourers' dwellings would find some useful suggestions in a little book, entitled "Healthy

* Healthy Moral Homes for Agricultural Labourers," 8vo., 34 plates. Published by the Author, P. Thompson, 24, High Street, Marylebone.
BLOCK OF SIX COTTAGES - EACH WITH FIVE ROOMS, CONCRETE WALLS, FLOORS AND ROOF, COST $4.00 TO EACH COTTAGE

PLANS

GROUND CHAMBER GROUND CHAMBER GROUND CHAMBER

TALL'S PATENT APPARATUS FOR CONSTRUCTING BUILDINGS

PLAN CHAMBER FLOOR

PLAN GROUND FLOOR

TWO SIX ROOM SEMI-ATTACHED HOUSES
Conrete Walls, Floors and Roofs

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

TRANVERSE SECTION ON LINE A B
TRIAL OF A STEAM FIRE ENGINE.

On the 27th ult., an interesting official trial took place at the Royal Dockyard, Deptford, with a large steam fire engine just constructed for this dockyard by Messrs. Merryweather & Sons. In general arrangement and construction, like those already supplied by the same firm for Devonport and Portsmouth dockyards and the Metropolitan Fire Brigade. Similar engines are likewise in hand, we are informed, for the dockyards of Woolwich and Chatham, and for the Russian and Belgian Governments.

The engine under notice has double cylinders and is arranged on the long steady stroke principle, with direct action between steam cylinders and pumps; the boiler being on the "Field" principle, now extensively employed both for stationary and portable purposes. The chief points aimed at in the designing of these engines have been simplicity, durability, efficiency, accessibility of the various parts, and facilities for repairing in cases of damage arising through the carelessness of attendants; especially in allowing the boilers to become short of water; as an instance of which we may mention that in the case of one of these engines recently delivered by the constructors, the boiler had been allowed to get short of water, and that although nearly the whole of the tubes were burned, the other parts of the boiler were not in any way injured; and the engine was returned in perfect working order within 14 hours; whereas had the boiler been of the usual vertical tubular construction, there can be no doubt that it would have been utterly destroyed.

The "Field" boiler, as applied to these engines, has, in numerous competitive trials against English and American engines, shown...
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

[September 1, 1866]

itself capable of raising steam in most cases from 3 to 4 minutes, and even on some occasions 10 minutes earlier than the boilers of competing engines, which is a great advantage in enabling an early attack to be made upon a fire. Another feature of these engines, and one which calls for no especial mention, is that water troubles all engines on the vertical system, viz., the excessive friction produced when pumping sandy water; amounting in many cases to 60 per cent. of the power of the engines, which have been known to work well during their early trials, but to decline in duty after a short period. This difficulty is overcome in Merryweather's engine by the peculiar construction of the pumps which have self-lubricating pistons, and discharge all sand and gritty matter through the valves without its passing through the barrels of the pumps.

At the trial on the 27th ult. which was considered highly satisfactory, the boiler was supplied with cold water; various pressures of steam being obtained as follows, viz., 5 lbs. per square inch in 4 minutes from time of lighting the fire; 20 lbs. in 5 minutes 30 seconds; 30 lbs. in 5 minutes 20 seconds; 40 lbs. in 7 minutes; 60 lbs. in 7 minutes 30 seconds; 80 lbs. in 8 minutes; 100 lbs. in 8 minutes 15 seconds; 100 lbs. in 8 minutes 30 seconds. The engine was then started, and in 5 minutes from the time of lighting the fire, a strong jet of water 11 inches in diameter was issuing from the nozzle, jets of various sizes were used, up to 2 inches in diameter, and four streams of 4 inches diameter were projected. All the jets were thrown to great heights and distances, and went with great force well over chimney shafts in its vicinity notwithstanding the strong wind. The hydraulic pressure was measured by various works and in the engine house by Mr. Saunders, master shipwright; Mr. Simmons, assistant engineer; and several other scientific men.

THE RESTORATION OF ST. DAVID'S CATHEDRAL.

The lower part of the great tower of St. David's Cathedral was in danger of falling, and new piers have recently been put in. The tottering condition of the tower needed prompt attention, and Mr. Geo. Gilbert Scott was invited to examine and report in 1862, upon this magnificent monument of the early ecclesiastical architecture of this country.

Mr. Scott's report was to the effect that the present structure was commenced about the year 1180, by Bishop de Leia at the exact time when the Romanesque or round arched style was in a state of transition into the pointed Gothic, and at the period when architecture was being freed from the barbarism of the days. The tower was commenced this time in the church of St. Cross, near Winchester, was built, also the eastern portions of Canterbury Cathedral, and the present Abbey of Glastonbury, all of which somewhat resemble St. David's Cathedral in style. The latter exhibits much beauty and refinement in its details, especially in the carved foliage and ornamental masonry, but it was rather backward in the adoption of the pointed arch. The whole of the building commenced in 1180 was prepared to be vaulted with stone on the "sexpartite" principle, but it is not evident that the vaulting was carried out.

In 1250 the great central tower fell in, severely injuring the choir and transept. One side of the ruined tower was left standing, that of the western arch with its two piers, so three sides of the tower with three arches were built up anew. In 1248 the building was much shaken by an earthquake, rendering much reconstruction necessary; chapels were extensively added, and about 1300, the Lady Chapel was either erected or greatly enlarged by Bishop David Martin, who probably contributed much of the piers to the time of its present height. Bishop Garely, who held the see from 1328 to 1347, had an insatiable appetite for building, so he enlarged and altered much of the cathedral, and besides erected the stupendous bishop's palace alongside. During his time the roof-screen was constructed, and several beautiful monuments introduced. In the next century Bishop Lloyd made further improvements, added a storey to the great tower, and reconstructed the gorgeous roof of the nave.

From the fifteenth century to the present time the cathedral has been falling into a disgraceful state of decay, inhabited principally by the owls and bats, and when Mr. Scott made his survey, this was by far the most perilous part of the building. Without any form of drain all round the cathedral to carry off the water already mentioned, taking out the two west piers of the tower and replacing them with new on the ancient model, restoring the tower and repairing and restoring the choir stalls and seats, repairing the organ, and repairing thoroughly the eastern chancel.

One of the most prominent objects of restoration was commenced about a year and a-half ago, by the difficult task of repairing the tower, on the same plan as that adopted a few years since in the preservation of the tower of the cathedral of Bayeux, in France. The tower of St. David's Cathedral is 124 feet high, 40 feet square externally, and weighs more than 4,000 tons. Mr. Clear, the resident architect, began by fixing braces inside and outside of the tower, and bolting its walls together to make it as much in one piece as possible, after which he screwed the sides of the tower in closer to each other. The bracing which consisted of massive ties of iron, of course took none of the weight of the tower.

He next constructed some incompressible foundations for shoring of the most massive description, the supports containing, in all, 17,000 cubic feet of timber under the north and west arches, and against the two western piers. The whole weight of the tower rested for a considerable length of time principally upon the shoresing upon oak needles passing through the spandrels of the arches, wrought-iron girders being placed across the angles. These girders were supported by logs pegged perpendicularly, each of the logs being composed of nine pieces of timber from 14in. square, bolted and framed together.

While the tower rested on the main shoring, the two western piers were gradually rebuilt beneath it, in good cement work and in small portions at a time, a movable system of shores being used to sustain the work in immediate connection with the parts operated upon. The north-west pier was commenced in January last, and finished in March, when the south-west pier was completed. In the course of the restorations relief has been found indicating that a Christian place of worship existed on the site of the cathedral before the time of Bishop de Leia, although a popular superstition in Pembroke, that St. Paul once landed at St. David's, was in no way corroborated. Several graves have been necessarily disturbed during the building operation, and Mr. Clear says of them, that beneath the daies in front of the roof-screen a grave was discovered, well built with ashlar, in three courses, and covered about three parts higher with the hard roughly hewn local stone. Only earth and a few pieces of leather were found in this grave.

Another grave close by was built of hewn stone in three courses, with a cavity at the east end to fit the head, very similar to those of the eleventh or twelfth centuries, composed of a single block of stone, undisturbed, the heads and general staff, the recent part of the handle of the staff, a chalice of thin silver, also a gold ring with an amethyst set in it. The pastoral staff head and portion of handle were of copper gilded, delicately chased, and in good preservation. It is conjectured that this might perhaps be the grave of Bishop Richard de Care, mentioned on the 1st of April, 1250, and buried, according to Leland, "prope altare crucif".
RECENT PROGRESS OF SCIENCE.*

By W. R. Grove, F.R.S.,

President, British Association for the Advancement of Science, 1866-67.

If our rude predecessors, who at one time inhabited the caverns which surrounded this town, could rise from their graves and see it in its present state, it may be doubtful whether they would have sufficient knowledge to be surprised.

The machinery, almost resembling organic beings in delicacy of structure, by which you fabricate products of world-wide reputation, the powers of matter applied to give motion to that machinery, are so far removed from what must have been the conceptions of the semibarbarians to whom I have alluded, that they could not look on them with intelligent wonder.

Yet this immense progress has all been effected step by step, now and then a little more sudden than at other times; but, viewing the whole course of improvement, it has been gradual, though moving in an accelerated rate. No longer is it not merely in those branches of natural knowledge which tend to improvements in economical arts and manufactures, that science has made great progress. In the study of our own planet and the organic beings with which it is crowded, and in so much of the universe, as vision, aided by the telescope, has brought within the scope of observation, the last century has surmounted any antecedent period of equal duration.

It would be difficult to trace out all the causes which have led to the increase of observational and experimental knowledge. Among the more thinking portion of mankind the gratification felt by the discovery of new truths, the expansion of faculties, and extension of the boundaries of knowledge have been doubtless a sufficient inducement to the study of nature; while, to the more practical minds, the reality, the certainty, and the progressive character of the acquisitions of natural science, and the enormously increased means which its applications give, have impressed its importance as a minister to prosperity and a contributor to ever-increasing material comforts, luxury, and power.

Though by no means the only one, yet an important cause of the rapid advance of science is the growth of associations for promoting the progress either of physical knowledge generally, or of special branches of it. Since the foundation of the Royal Society, more than two centuries ago, a vast number of kindred societies have sprung up in this country and in Europe. The advantages conferred by these societies are manifold; they enable those who are devoted to scientific research, to combine, compare, and check their observations, to assist, by the thoughts of several minds, the promotion of the inquiry undertaken; they contribute from a joint purse to such efforts as their members deem most worthy; they afford a means of submitting to a competent tribunal notices and memoirs, and of obtaining for their authors and others, by means of the discussions which ensue, information given by those best informed on the particular subject; they enable the author to judge whether it is worth his while to pursue the subjects he has brought forward, and they defray the expense of printing and publishing such researches as are thought deserving of it.

These advantages, and others might be named, pertain to the Association, the 36th Meeting of which we are assembled to inaugurate; but it has, from its inception, had an intrinsically interesting and peripatetic character, advantages which belong to none of the societies which are fixed as to their locality.

Among these are the novelty and freshness of an annual meeting, which, while it brings together old Members of the Association, many of whom only meet on this occasion, always adds a quota of youth, bringing new blood, and varying the social character of our meetings.

The visits of distinguished foreigners, whom we have previously known by reputation, is one of the most delightful and improving of the results. The wide field of inquiry, and the character of communications made to the Association, including all branches of knowledge and science, in the notices of an interesting observation or experiment, to the most intricate and refined branches of scientific research, is another valuable characteristic.

Lastly, perhaps the greatest advantage resulting from the annual visits of this great parliament to new localities is that, while it imparts fresh local knowledge to the visitors, it leaves behind stimulating memories, which rouse into permanent activity dormant or timid minds—an effect which, so far from ceasing with the visit of the Association, frequently begins when the visit terminates.

Every branch of physical science must be anxious to see it recognized by those institutions of the country which can to the greatest degree promote its cultivation and reap from it the greatest benefit. You will probably agree with me that the principal educational establishments on the one hand, and on the other the Government, in many of its departments, are the institutions which may best fulfil these conditions. The earlier the mind is trained to a pursuit of any kind, the deeper and more permanent are the impressions received, and the more service can be rendered by the students.

Little can be achieved in scientific research without an acquaintance with it in youth; you will rarely find an instance of those who have early acquired the ethos resulting from a scientific education. I desire to make no complaint of the tardiness with which science has been received at our public schools; on the contrary, with some exception the present century has surpassed any antecedent period of equal duration.

Nor should I ever wish to see the study of languages, of history, of the fine arts, of those refined associations which the past has taught us to prize, neglected; it is to be feared that the number of so-called educated men who, travelling by railway, voyaging by steamboat, consulting the almanac for the time of sunrise or full-moon, have not the most elementary knowledge of a steam-engine, a barometer, or a quadrant; and who, at the time of the eclipse of the Sun or Moon, will not be ashamed of knowing the principles of an air-pump, an electric machine, or a telescope, and will not, as Bacon complained of his contemporaries, despise such knowledge as something mean and mechanical.

To assert that the great departments of Government should encourage the physical sciences may appear a truism, and it is but of late that it has been seriously done; now, the habit of consulting men of science on important questions of national interest is becoming a recognized practice, and in a time, which may seem long to individuals, but is short in the history of a nation, a more definite sphere of usefulness for national purposes will, I have no doubt, be provided for those duly qualified men who may be content to give up the more tempting study of abstract science for that of its practical applications. In this respect the Report of the Kew Committee for this year affords a subject of congratulation to those whom I have the honour to address. The Kew Observatory, the petted child of the British Association, and the faithful and industrious Institute of the Meteorological Department, have both been encouraged and assisted by the Government; and if so, while it will not, I trust, lose its character of a home for unrivaled physical research, it will have super-added the Meteorological Department of the Board of Trade with a staff of skilful and experienced observers.

This is one of the results which the general progress of science, and the progress of the country in which you have produced; but I do not propose on this occasion to recapitulate the special objects attained by the Association, this has been ably done by several of my predecessors; nor shall I confine my address to the progress made in physical science since the time when my able and esteemed friend and predecessor addressed you last; but the objects which will be read at your Sections, details of every step which has been made in science since our last Meeting will be brought to your notice, and I have no doubt fully and freely discussed.

I purpose to submit to you certain views of what has within a comparatively recent period been accomplished by science, what have been the steps leading to the attained results, and
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

September 1, 1868

what, as far as we may fairly form an opinion, is the general character pervading modern discovery.

It seems to me that the object we have in view would be more nearly approached, by each President, chosen as they are in succession as representing different branches of science, giving on these occasions either an account of the progress of the particular branch of science he has cultivated, when that is not of a very large and general character, or a special his own view of the general progress of science; and though the will necessarily involve much that belongs to recent years, the confining a President to a mere résumé of what has taken place since our last Meeting would, I venture with diffidence to think, limit his main usefulness, and render his discourse rather an annual register than an exposition.

I need not dwell on the common-place but yet important topics of the material advantages resulting from the application of science; I will address myself to what, in my humble judgment, are the lessons we have learned and the probable prospects of improved natural knowledge.

One word will give you the key to what I am about to discourse on; that word is continuity, no new word, and used in no new sense, but perhaps applied more generally than it has hitherto been. We shall see, unless I am much mistaken, that the development of observational, experimental, and even deductive knowledge is either attained by steps so extremely small as to form reals; or, on the contrary, results apparently separate from any co-ordinate phenomena have been attained, that then, by the subsequent progress of science, intermediate links have been discovered uniting the apparently segregated instances with other more familiar phenomena.

Thus the more we investigate, the more we find that in existing phenomena graduated from the like to the seemingly unlike prevails, and in the changes which take place in time, gradual progress is, and apparently must be, the course of nature.

Let me now endeavour to apply this view to the recent progress of some of the more prominent branches of science.

As an example, from the time the earth was considered a flat plain bounded by a flat ocean—when the sun, moon, and stars were regarded as lanterns to illuminate this plain,—each successive discovery has brought it similitudes and analogies between this earth and many of the objects of the universe with which our senses, aided by instruments, have made us acquainted. I pass, of course, over those discoveries which have established the Copernican system as applied to our sun, its attendant planets, and their satellites. The proofs, however, that gravitation is not confined to our solar system, but pervades the universe, have received many confirmations by the labours of Members of this Association; I may name those who have held the presidency, Lord Rosse, Lord Wrottesley, and Sir J. Herschel, the two latter having found the orbits of double stars, the former to those probably more recent systems called nebulae. Double stars seem to be orbs analogous to our own sun and revolving round their common centre of gravity in a conic section curve, as do the planets with which we are more intimately acquainted; but the nebulae present more difficulty, and some doubt has been expressed whether gravitation, such as we consider it, acts with those bodies (at least those exhibiting a spiral form), as it does with us; possibly some other modifying influence may exist, our present ignorance of which gives rise to the apparent difficulty. These observations, another class of observations quite recent in its importance, and which has formed a most interesting subject of contribution to the Reports and Transactions of this Association; I allude to those on Meteories, at which our lamented Member, and to many of our valued friends, Prof. Baden Powell among them, have been industriously laboured, for investigations into which a Committee of this Association is formed, as a series of star-charts for enabling observers of shooting-stars to record their observations. The first of these was laid before the last Meeting of the Association by Mr. Glaisher.

It would occupy too much of your time to detail the efforts of Bennett, Schwinge, the late Sir J. Lubbock, and others, as applied to the star-charts for aiding the observation of meteories which Mr. Alexander Herschel, Mr. Brayley, Mr. Sorby, and others are now studying.

Dr. Olmstead explained the appearance of a point from which the lines of flight of meteors seem to radiate, as being the prospective vanishing point of their parallel or nearly parallel courses appearing to an observer on the earth as it approaches them. The uniformity of position of these radiant points, the nearly correct observation from the direction of the distances, and the velocities of these bodies, the circumstance that their paths intersect the earth's orbit at certain definite periods, and the total failure of all other theories which have been advanced, while there is no substantial objection to this, afford evidence almost amounting to proof that these are cometical bodies moving in the interplanetary space between the earth and some perhaps round planets. This view gives us a new element of continuity. The universe would thus appear not to have the extent of empty space formerly attributed to it, but to be studded with the larger and more visible masses with smaller planets, if the term be permitted to be applied to meteorites. Observations of these, which meteors appear in greatest numbers—at Greenwich by Mr. Glaisher, at Cambridge by Prof. Adams, and at Hawkhurst by Mr. Alexander Herschel—and every preparation is made to secure as much accuracy as can, in the present state of knowledge, be secured for such observations.

The number of known asteroids, or bodies of a smaller size than what are termed the ancient planets, has been so increased by numerous discoveries, that instead of seven we now count eighty-eight as the number of recognized planets—a field of discovery with which the name of Hindu will be ever associated.

If we add these, the smallest of which is only three or four miles in diameter, the planetary bodies have been described, and if we were to apply the same scrutiny to other parts of the heavens as has been applied to the zone between Mars and Jupiter, it is no far-fetched supposition to suppose that between these asteroids and the meteorites, bodies of intermediate size exist until the space occupied by our solar system becomes filled up with planetary bodies varying in size from that of Jupiter (1340 times larger in volume than the earth), to that of a cannon-ball or even a pistol-bullet.

The researches of Leverrier on the intra-murcular planets come in aid of these views; and another half century may, and not improbably will, enable us to ascertain that the now seemingly vacant interplanetary spaces are occupied by smaller bodies which have hitherto escaped observation, just as the asteroids had until the time of Olbers and Piazzi. But the evidence of continuity as pervading the universe does not stop at telescopic observation; chemistry and physical optics bring us new proofs.

Those meteoric bodies which have from time to time come so far in their course as to fall upon its surface, give on analysis metals and oxides similar to those which belong to the structure of the earth—they come as travellers bringing specimens of minerals from extra-terrestrial regions.

In a series of papers recently communicated to the French Academy, M. Daubrée has discussed the chemical and mineralogical characteristics of meteoric bodies, especially those associated with the rocks of the earth. He finds that the similarity of terrestrial rocks to meteorites increases as we penetrate deeper into the earth's crust, and that some of the deep-seated minerals have a composition and characteristics almost identical with meteorites (olivine, herzolite and serpentine, for instance, closely resemble them); that as we approach the surface, rocks having similar components with meteorites are found, but in a state of oxidation, which necessarily much modifies their mineral character, and which, by involving secondary oxygenized compounds, must also change their chemical constitution. By experiments he has succeeded in forming from terrestrial rocks substances very similar to meteoric bodies, and he has shown, though by no means identity, is established between this earth and those wanderers from remote regions, some evidence, though at present incomplete, of a common origin.

Surprise has often been expressed that, while the mean specific gravity of this globe is from five to six times that of water, the mean specific gravity of meteoric bodies is about 3. This has long seemed to me that there is no ground for wonder here. The exterior of our planet is to a considerable depth oxidized; the interior is in all probability free from oxygen, and whatever bodies exist there are in a reduced or deoxidated state, if so, their specific gravity must necessarily be higher than that of these oxides or their compounds, and that some of the deep-seated minerals have a higher specific gravity than the average of those on the surface; olivine, for instance, has a specific gravity of 3.3. There is therefore no à priori improbability that the mean specific gravity of the earth should notably exceed that of its surface; and if we go further and suppose the
of the earth to be formed of the same ingredients as the exterior, minus oxygen, chloride, bromide, &c., a specific gravity of 5 to 6 would not be an unlikely one. Many of the elementary bodies entering largely into the formation of the earth's crust are as light or lighter than water,—for instance, potassium, sodium, &c.; others, such as sulphur, silicon, aluminium, have from two to three times its specific gravity; others, again, as iron, copper, zinc, tin, exceed it twenty times; while gold, lead, gold, platinum, &c., are much more dense,—but, speaking generally, the more dense are the least numerous. There seems no improbability in a mixture of such substances producing a mean specific gravity of from 5 to 6, although it by no means follows, indeed the probability is rather the other way, that the proportion of the substances in the interior of the earth are the same as on the exterior. It might be worth the labour to ascertain the mean specific gravity of all the known minerals on the earth's surface, averaging them in the ratios in which, as far as our knowledge goes, they quantitatively exist, and assuming them to exist without the oxygen, chloride, &c., with which they are, with some rare exceptions, invariably combined on the surface of the earth: great assistance to the knowledge of the probable constitution of the earth might be derived from such an investigation.

While chemistry, analytic and synthetic, thus aids us in ascertaining a relationship between the various relations in composition to other planets, to the sun, and to more distant suns and systems is aided by another science, viz. optics.

That light passing from one transparent medium to another should carry with it evidence of the source from which it emanates, would, until lately, have seemed an extravagant supposition; but probably could we read it, everything contained in itself a large portion of its own history.

I need not detail to you the discoveries of Kirchhoff, Bunsen, Miller, Huggins, and others, they have been dilated on by my predecessor. Assuming that spectrum analysis is a reliable indication of the presence of given substances by the position of their spectral lines exhibited when they are either by transverse dark lines when light is transmitted through their vapours, though Plücker has shown that with some substances these lines vary with temperature, the point of importance in the view I am presenting to you is, that while what may be called comparatively neighbouring cosmical bodies exhibit lines identical or nearly so, some are shown by the flames of this planet, as we proceed to the more distant appearances of the nebula we get but one or two of such lines, and we get but one or two new bands not yet identified with any known to be produced by substances on this globe.

Within the last year Mr. Huggins has added to his former researches the record of observations of the spectrum of a comet (comet I of 1866), the nucleus of which shows but one bright line, while the spectrum formed by the light of the coma is continuous, seeming to show that the nucleus is gaseous while the coma would consist of matter in a state of minute division shining by reflected light: whether this be solid, liquid, or gaseous is doubtful, but the author thinks it is in a condition analogous to that of fog or cloud. The position in the spectrum of the bright line furnished by the nucleus is the same as that of nitrogen, which also is shown in some of the nebulae.

But the most remarkable achievement by spectrum analysis is the record of observations on a temporary star which has suddenly faded from view, and on the comet of 1866, about a degree S.E. of the star α. When it was first seen, May 12th, it was nearly equal in brilliancy to a star of the second magnitude; when observed by Mr. Huggins and Dr. Miller, May 16th, it was reduced to the third or fourth magnitude. Examined by these observers with the spectroscopic instruments, it gave a number of new bands; they state unlike that of any celestial body they had examined.

The light was compound and had emanated from two different sources. One spectrum was analogous to that of the sun, viz., formed by the light of an incandescent solid or liquid photographed on a photographic plate, while the second spectrum, formed by the absorption of light from the first, showed almost the characteristic spectre of a state of lope cooler than itself. The second spectrum consisted of a few bright lines, which indicated that the light by which it was formed was emitted by matter in the state of luminous gas. They consider that, from the position of the two bright lines, the gas must be probably hydrogen, and from their brilliancy compared with the light of the photosphere the gas must have been at a very high temperature. They imagine the phenomena to result from the burning of hydrogen with some other element, and that from the resulting temperature the photosphere is heated to incandescence.

There is strong reason to believe that this star is one previously seen by Arago and Sir J. Herschel, and that it is a variable star of long or irregular period; it is also notable because of its spectrum, and the peculiarities of the absorbed light from it, especially in connection with the propagation of the light from it, and the results of the recent observations of the stars. The time of its appearance was too short for any attempt to ascertain its parallax; it would have been important if it could have been established that it is not a near neighbour, as the magnitude of such a phenomenon must depend upon its distance. I forbear to add any speculations as to the cause of this most singular phenomenon: 

The knowledge given us by these observations, it is a great triumph to have caught this fleeting object, and obtained permanent records for the use of future observers.

It would seem as if the phenomenon of gradual change obtained towards the remotest objects with which we are at present acquainted, and that the further we penetrate into space the more unlike to those we are acquainted with become the objects of our examination,—sun, planets, meteorites, earth similarly though not indenitically constituted, stars differing from each other and from our system, and nebula more remote in space and resembling more and more the sun, until at last the sun is lost in the vastness of space,

While we thus can to some extent investigate the physical constitution of the most remote visible substances, may we not hope that some further insight as to the constitution of the nearest, viz., our own satellite, may be given us by the class of researches? The question whether the moon possesses any atmosphere may still be regarded as unsolved. If there be any, it must be exceedingly small in quantity and highly attenuated. Calculations, made from occultations of stars, on the apparent differences of the semidiameter of the bright and dark moon give an amount of difference which might indicate a minute atmosphere, but which Mr. Airy attributes to irradiation.

The appearance of her craters is not unlike that seen on the surface of some metals, such as bismuth, or, according to Professor Phillips, silver, when cooled from fusion and just previous to solidifying; and it might be a fair subject of inquiry whether, if there be any coating of oxide on the surface, it may not be so thin as to disguise the form of the congealed metallic masses, as they may have set in cooling from fused substance. M. Chacornac's recent observations lead him to the belief that the craters were the result of a single explosion, which raised the surface as a bubble and deposited its débris around the orifice of eruption.

The eruptions on the surface of the moon clearly did not take place at one period only, for at many parts of the disk craters may be seen encroaching on and disfiguring more ancient craters, sometimes to the extent of three or four successive displacements: two important questions might, it seems to me, be solved by an attentive examination of such portions of the moon. By observing carefully with the most powerful telescope the character of the ridges thus successively formed, the successive states of the lunar surface at different epochs might be elucidated, and then the cause of the gradual red tinge may be supposed to be due to the continuous erosion of the moon.

M. Chacornac considers that the seas, as they are called, or smoother portions of the lunar surface have at some time made inroads on anterior plains, and he further considers that the sea, for the most part, must have been in a fused, liquid, semiliquid, or alluvial state long after the solidifying of other portions of it. It would be difficult to suppose that this state was one of igneous fusion, for this could hardly exist over a large part of the surface without melting up the remaining parts; on the other hand, the total absence of any signs of water, and of any, if any, only
the most attenuated, atmosphere, would make it equally difficult to account for a large diluvial formation.

Some substances, like mercury on this planet, might have remained liquid after others had solidified; but the problem is not one which needs more examination and study before any positive opinion can be pronounced.

This is no proper subject for a work on the subject of lunar physics without recording the obligation we are under to our late President for his most valuable observations and for his exertion in organizing a band of observers devoted to the examination of this our nearest celestial neighbour, and to Mr. Nasmyth and Mr. Du Cane for their important graphical and photographic contributions to this subject. The granular character of the sun's surface observed by Mr. Nasmyth in 1860 is also a discovery which ought not to be passed over in silence.

Before quitting the subject of Astronomy I cannot avoid expressing a feeling of disappointment that the achromatic telescope, which has rendered such notable service to this science, still retains in practice the great defect which was known a century ago at the time of Hall and Dollond, namely, the inaccuracy of definition arising from what was termed the irrationality of the spectrum, or the incommensurate divisions of the spectra formed by flint and crown glass.

The results obtained by Blair have remained inoperative from the circumstance that evaporating liquids being employed between the lenses, a want of permanent uniformity in the instrument was experienced; and notwithstanding the high degree of perfection to which the grinding and polishing object-glasses has been brought by Clarke, Cooke, and Mertz, notwithstanding the greatly improved instrumental manufacture, the defect to which I have adverted remains unrecovered and an eyepiece to the observer with the refracting telescope.

We have now a large variety of different kinds of glass formed from different metallic oxides. A list of many such was given by M. Jacquelain a few years back; the last specimen which I have found in my supply was a glass formed from the metal thallium by Mr. Lamy. Among all these could no two or three be selected which, having appropriate refracting and dispersing powers, would have the coloured spaces of their respective spectra if not absolutely in the same proportions, at all events much more nearly so than those of flint and crown glass? Could not, again, oily or resinous substances sharing much action on the green or middle colour of the spectrum, such as castor oil, camphor, &c., be made use of in combination with glass lenses to reduce if not annihilate this signal defect? This is not a problem to the solution of which there seems an insuperable difficulty; the reason why it has not been brought more to the fore of our attention I think is that the great practical opticians have no time at their disposal to devote to long tentative experiments and calculations, and on the other hand the theoretic opticians have not the machinery and the skill in manipulation requisite to give the appropriate degree of excellence to the materials with which they experiment; yet the result is worth labouring for, as, could the defect be remedied, the refracting telescope would make nearly as great an advance upon its present state as the achromatic did on the single lens refractor.

While gravitation, physical constitution, and chemical analysis by the spectrum show us that matter has similar characteristics in other worlds than our own, when we pass to the consideration of those other attributes of matter which were at one time supposed to be peculiar kinds of matter itself, or, as they were called, imponderables, but which are now generally, if not universally, recognized as forces or modes or motion, we find the evidence of continuity still stronger.

When all that was known of magnetism was a piece of steel rubbed against a particular mineral had the power of attracting iron, and, if freely suspended, of arranging itself nearly in a line with the earth's meridian, it seemed an exceptional phenomenon. When it was observed that amber, if rubbed, or if any part of attracting living bodies, this also seemed something peculiar and anomalous. When electricity and magnetism and electricity? forces so universal, so apparently connected with matter as to become two of its invariable attributes, and that to speak of matter not being capable of being affected by these forces would seem almost as extravagant as to suppose it not being affected by gravitation.

So with light, heat, and chemical affinity, not merely is every form of matter with which we are acquainted capable of manifesting all these modes of force, but so-called matter supposed incapable of such manifestations would to most minds cease to be matter.

Further than this it seems to me (though, as I have taken an active part for many years, now dating from a quarter of a century, in promoting this view, I may not be considered an impartial judge) that it is now proved that all these forces are so invariably connected inter se and with motion as to be regarded as modifications of each other, and as resolving themselves objectively into motion, and subjectively into that which produce or resists motion, and which we call force.

(The to be concluded in our next.)

THE INTERCOLONIAL EXHIBITION OF AUSTRAVASIA.

This site fixed upon for the building in which the above exhibition will be held, is situated at the rear of the Public Library at Melbourne, and will no doubt be found a convenient position on account of its proximity to the more central parts of the city. The building like most of those in which exhibitions are held will be of a comparatively temporary nature, but some portions which are being constructed of greater solidity than the rest, are intended to form part of extended extensions of the present library.

The total amount of space to be provided is about 35,000 superficial feet, about one half of which is already applied for, and it is anticipated that the building will be completed and the exhibition opened by about the 1st November. The building will consist of a central circular hall, a great hall, and two wings or annexes, beside one or two smaller apartments. The central or circular hall is 75 feet in diameter, and 50 feet high; it will form a vestibule or entrance hall to the rest of the building, and will be made available for the display of articles of an artistic nature. On each side of it there will be an open space about 75 feet square; one of these will be used for exhibiting such articles as are not liable to be damaged by exposure to weather; while in the other there will be held a series of flower shows. Immediately behind the central hall is the great hall, 220 feet by 84 feet, consisting of a central nave surmounted by a semicircular roof 80 feet high, and two side aisles of which each is 100 feet long and is separated by means of clerestory windows. The two wings will be about 170 feet long by 28 feet wide; one will be used as a picture gallery, and in the other will be placed the machinery in motion. In this latter there will also be exhibited several manufacturing processes including pottery, iron founding, quartz crushing, gas making, &c. The whole cost of the building will be about £25,000, of which not more than about £3,000 will be expended on purely temporary work. The architects are Messrs. Reed and Barnes, of Melbourne, and the contractors Messrs. Cunningham and Hilton.

Ancient Mining.—Interesting discoveries have lately been made in the San Domingo mines of Spain, showing the methods of mining adopted by the ancients. In some of the mines the Romans dug draining galleries nearly three miles in length, but in others the water was raised by wheels to carry it over the rocks that crossed the drift. Eight of these wheels have recently been discovered by the miners who are now working in the same old mines. The wheels are made of wood, the arms and felloes of pine, and the axle and its support of oak, the fabric being remarkable for the lightness of its construction. It is supposed that these wheels cannot be less than fifteen hundred years old, and the wood is in a perfect state of preservation, owing to its immersion in water charged with the salts of copper and iron. From their position and construction the wheels are supposed to have been worked as tread-mills, by men standing with naked feet upon one side. The water was raised by one wheel into a basin, from which it was raised to another stage by the second wheel, and so on for eight stages.
THE HYDRAULIC LIFT GRAVING DOCK.

By EDWIN CLARK, M. Inst. C.E.

(Continued from page 242)

Mr. Edwin Clark remarked that his object was to court the fullest discussion on the subject of these docks, and that with that view he had endeavoured to make the paper as comprehensive in its details as he could. He took this opportunity of expressing his obligations to those gentlemen who had assisted him in bringing these docks to their present state (more especially to Mr. Archibald and the late Robert Stephen, Esq.) not only in the designs, but also in the financial part of the undertaking, by taking upon themselves personally a large share of the first outlay. He had also wished to thank Mr. John Heppel for the very ingenious suggestion, which formed the basis of the design of the new type of excavating groups, instead of in the mode originally intended. Mr. Clark expressed his readiness to elucidate any point upon which further information was desired.

Mr. Abernethy inquired whether the statement of cost included all the necessary excavation in connection with the lift, in fact all the preparations for receiving the machinery. Some information on that point was necessary, to enable a comparison to be made of the cost of the adit excavations and the dock. He did not matter whether the excavation was as stated. It was, however, as far as he understood, that the cost of the operation of lifting was about £3 per vessel. He presumed that was the average price.

Mr. Clark replied, that the cost of the excavations had not been given. Obviously the expense for receiving the pontoons, if any were required, would form a considerable item in the cost of the work. In places, however, the whole work consisted simply of sinking canals. But he would before the detail of the excavation, give this information in its place. The cost was, as an average for all the vessels lifted. Mr. Charles Capper, having had opportunity of dealing with a great deal of the operations of this dock, was satisfied that, as a mechanical contrivance, it was perfect. The commercial success of the undertaking was, however, which was the real test, which came more within his own province; for however successful it might be from a mechanical contrivance, if it were not commercially successful it would be of no use. The Author had described the circumstances under which this dock was a commercial failure, and this was the first instance. It was assumed, incorrectly, that the mere charge for lifting the ship, and the charge for the use of the docks in order to get the repairs of the vessels. This Company having at first no mechanical appliances for repairs, and being subject to the competition referred to, the commercial failure of the project would be the cause. On the contrary, it was the cost of the docks which was more within his own province; and if it were from 20 to 30 per cent, and the cost of the docks was rather more than 2 per cent of the outlay. It was obvious that, to make these docks, or any ordinary graving docks, successful speculations, the proprietors must be able to offer a very large return on the capital invested in repairing the ships. If they did that, it was, as was the case in this instance, they would lose money on even a beneficial operation.

The last year before the Thames Graving Dock Company undertook repairs, the loss upon this dock was about £4,000 per annum. Since the repairing had been superannuated, although it had only been as yet perfectly carried on for nine months, a profit had been realized of between £21,000 and £22,000 per annum, which, of course made a very material difference in its commercial character. This dock experienced another drawback. Being the first of the kind on the Thames, many modifications were required to adapt it to the peculiar requirements of the port. These were all additional expenses, of course, as usual, charged to capital; and when revenue had to pay capital employed in making experiments, it affected the result. He was bound to say, that the undertaking was not so profitable as he thought it would be. Some he wished to see it; and he believed before long it would be one of a highly remunerative character.

Mr. F. Heigel endorsed all that had been said as to the unremunerative character of the Thames, and that more than 2½ per cent, or 3 per cent, upon the outlay. The repairing of ships formed no part of the business there. At Southampton there were three dry docks, one of which could accommodate any ship yet built on the Thames: Mr. A. Giles said, the paper contained much that was interesting, and the mechanical arrangements of this dock were no doubt of the most admirable and perfect character; but he thought the ordinary graving docks would have been far more advantageous. This dock could be compared with those of ordinary graving docks; it was necessary to be informed what had been the total cost of the existing works.

Mr. J. Scott Russell, V.P., thought additional information was required to enable a comparison to be made between this system and

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* Headed before the Institution of Civil Engineers.
the "Mercy" was repaired. In this construction of floating-docks there was an end-gate, which was lowered to admit of the vessel entering, and the gate being afterwards raised, the water was pumped out of the dock. Many alterations of the Screw Dock, in 1776, of 1780, and of having constructed a "large portable dock in which to float vessels."

As regarded the more modern history of floating-docks, the Author had alluded to the box dock and the sectional dock, both of which had been invented about 1765, but he had not, so far as he recollected, used in that country prior to either of the other two docks; and Mr. Bramwell was somewhat surprised at this, as, in its modified construction, it appeared to him to be one that ought to have found favour with those who were in search of new particular objects. The first was a dock which, from its original construction, was known in the United States as the Screw Dock, and which had been afterwards worked by hydraulic power. He had placed on the wall a rough drawing, showing the effects of this dock, which had been constructed with a view to the idea that it consisted of two parallel rows of piling placed at right angles to the shore; these rows of piling being wide enough apart, sufficiently rooey, and in a sufficient depth of water to take in between them the largest ships the dock was competent to lift. The piles in each row were connected at the tops by timbers, on which was a gangway. From one row of piles to the other there were, at frequent intervals, transverse timbers. These timbers were lowered into the water, and the ships to be docked brought over them. At each end of each timber there was a cable for suspending the ship. The timbers were suspended, and passed over pulleys placed on the frames connecting the heads of the piles, and then all the chains on each side were connected to a horizontal traction-bar, which was a very strong wooden bar extending the whole length of the dock, and supported on iron pillars, one of which was a powerful hydraulic cylinder, and on this being worked, the traction-bar was moved endways, and thereby the whole of the chains attached to it were uniformly drawn; and in this manner the presses on the two sides acted in unison, the relative rate, on which the pressure of the water was simultaneously and uniformly raised, lifting the vessel that was upon them out of the water. He had seen the dock when New York in 1852, and he believed it had been in operation for many years prior to that date, and with perfect success. It appeared to him to be interesting as regarded the present paper, to the lifting of vessels by means of hydraulic presses.

Having made these few remarks upon some points omitted from the history of the dock and of diving boats, and if the Author had coupled up the system, came not improperly the consideration of the operations which took place in the Hydraulic Lift Dock, when raising vessels by the system of presses at each side of the dock. It was quite clear that the Author had immediately upon examining the dock, there was no remedy whatever against the vessel tilting either sideways or endways in the act of being lifted, and the Author had given well-merited praise to Mr. Heppel, for the suggestion of dividing the presses into three distinct groups. No doubt by this arrangement perfect command had been obtained over the vessel when leaving the lift horizontal; but this arrangement of grouping did not get over the fact, that the presses at the ends were exerting the same upward force as those in the middle; that was to say, a force representing the average load, and therefore being distributed uniformly. If at the ends the blister at once was not a property peculiar to the dock in consideration, it would be found that it existed in the New York Screw Dock, to which he had just referred, and it existed also in the Sectional Dock. The Author, therefore, in availing himself of the information in the dock to support the blisters, had done more than had been done in previous docks, nor might there be done in any other dry dock; at the same time he was glad to find that the Author approved of that which he (Mr. Bramwell) believed to be a most useful precaution in the docking of ships.

He would now go to another point which was raised by the Author which was this—that, in his judgment, not only was it unnecessary that the bed on which a vessel was received while being docked should be rigid, but that it was absolutely undesirable that it should be so. Now he must say he entirely dissented from this view. For although at the present day there were many iron ships which were so well built as to be efficient girders in themselves, and although even wooden ships were more or less rigid, and the pressed and bruised would be somewhat when they were little more than an assemblage of timbers side by side without proper tussing and fastening, nevertheless he considered that a properly-constructed dock should be one in which any vessel might repose in the certainty of not being called to slip upon its own strength as a girdr to compensate for the want of strength in the dock, and where, therefore, a ship, however weak in its construction, or however old or damaged, might be taken with the assurance it would not give way.

To explain himself still further, he might say that when he had been consulted on the subject of floating docks, he had laid it down as an axiom, that the dock, if properly made, ought to possess so much likeness to a stone dock in its rigidity, that if a ship placed in the dock were a poor one, there might be various slacks of water to one another, although the weight of the various silos would, if of equal thickness, be very different. As bearing on this point of the difference of weight per foot run, he wished to call attention to the Author's mode of taking the weight of a ship, which he had done, as being, in extreme cases of armour-plated vessels, 20 tons per foot run, or 6,000 tons for a ship 300 feet in length. But Mr. Bramwell objected to the construction of a dock being based on the assumption, that a vessel had an uniform weight per foot run, but that foot run, but he had not so much as 7 tons. The assumption, on the part of the Author, of uniformity of weight per foot run must, he thought, be admitted to be a mistake; and yet, upon this theory alone could the practice of a non-rigid bed be admitted, and certainly the Author's novel view of vessel building had put forward as his ideal of excellence, viz., a sheet of india rubber large enough to secure the vessel.

Having thus endeavoured to explain the reasons why non-rigid beds were undesirable, he thought it ought to be said that practice of ship-builders, to show that that practice coincided with the principles he had been advocating. It would be admitted that in building vessels, the greatest possible pains were taken to obtain a thoroughly solid bottom for the slip-way whereas in dry docks, they were built in and it was well known that considerable damage had arisen from the ground of a slip-way having occasionally yielded in parts. This showed the importance attached by ship-builders to having a rigid bed on which to build a ship. It seemed to him that which required a rigid support while being built; and he did not see, on that point, to be allowed to refer to the very pertinent observation made by Mr. Scott Russell, that if a ship got out of shape while afloat, the thing wanted in repair was a dock that should bring her back into shape. Mr. Scott Russell, in about twelve years ago, an impression existed in the mind of an inventor, that a rigid bottom to a dock was a bad thing; and he proposed to remedy this, by placing on the bottom of a stone dock a number of small hydraulic presses, on which the vessel, in lieu of resting on the ordinary keel blocks. These presses were all to be connected by pipes, so that they might adjust themselves to the pressure of the keel. This arrangement was tried in one dock in London; but, as might be supposed to a novel view, adverse remarks were expected, but none; it was found to be injurious to the vessel, and had to be removed, and the rigid system of blocks restored.

It appeared to him that following upon this reference, to the effect of engineering the docks, and of docks and of diving boats, was coupled up a system, and the Author, had given well-merited praise to Mr. Heppel, for the suggestion of dividing the presses into three distinct groups. No doubt by this arrangement perfect command had been obtained over the vessel when leaving the lift horizontal; but this arrangement of grouping did not get over the fact, that the presses at the ends were exerting the same upward force as those in the middle; that was to say, a force representing the average load, and therefore being distributed uniformly. If at the ends the blister at once was not a property peculiar to the dock in consideration, it would be found that it existed in the New York Screw Dock, to which he had just referred, and it existed also in the Sectional Dock. The Author, therefore, in availing himself of the information in the dock to support the blisters, had done more than had been done in previous docks, nor might there be done in any other dry dock; at the same time he was glad to find that the Author approved of that which he (Mr. Bramwell) believed to be a most useful precaution in the docking of ships.
of the tendency would be in a very rapid ratio, that was to say, it would be in the ratio of the square of the number of chambers into which the dock was divided by bulkheads; so that a dock divided by three bulkheads into four chambers would only have \( \sqrt[3]{4} \) the tendency to turn over that a dock would have in which there were not any bulkheads.

Mr. Bramwell, slide 3, said, that at the dock door the cost of water over the sill at ordinary spring tides; No. 2, 200 feet long, 40 feet wide, and 16 feet 3 inches of water over the sill; No. 3, 400 feet long, 94 feet 6 inches wide, and 23 feet 3 inches of water over the sill; No. 4, 200 feet long, 69 feet 6 inches wide, and 20 feet 3 inches of water over the sill; No. 5, 350 feet long and 69 feet 6 inches wide, and depth of water over the sill 22 inches 3 inches—making a total length of docks of 1,600 feet, which had been constructed at a cost of $285,000. Those were instances of greatest economy and best comparison. It was a fact that the most expensive character, and it was not therefore a fair subject of comparison with the Hydrostatic Lift system; yet it would seem, from these examples, the Author had arrived at the conclusion, that the greatest expense was the cost of necessary submergence of all the cases, even impracticable. But the cost of the Hydrostatic Lift had been $65,705 for the machinery, and $21,427 for the machinery and works connected with the lift, making a total cost of $88,132; the results of which is, that the Author had been to provide seven pontoons of an aggregate length of 1,496 feet.

Mr. Aernethw, during late years, constructed a number of graving docks at present in use, and proved to be very effective.
ON SOME OF THE ARTISTIC FEATURES OF THE ESSEX COTTAGES.*

BY THE REV. E. S. COXIN.

This title is not only too ambitious, but not strictly accurate, as I shall embrace in my remarks not only the cottages only, but farm-houses, in fact, any dwelling-house, under the rank of the mansions of the squire or nobleman. These have been often well described and illustrated in works easily accessible to all; but the cottages and farm-houses left us by our forefathers in past ages have not received the attention which I think they deserve. I cannot but think that it would be well worth the while for some one really capable to undertake this subject and work it out; to illustrate the principle of design which these old houses exhibit; to endeavour to classify them as to date; and to publish careful illustrations of good examples. I have not the knowledge or skill for anything of the sort, and only venture to skim the surface of the subject, and direct the attention of some able hand towards it.

I do not allude now in any way to the ground plan of these old homesteads—their arrangement of rooms—their appliances for the comfort and decency of their inhabitants at the time of their erection—or their capabilities for meeting the necessities of our modern life; I speak simply of their external form and design.

Nor is it impossible to deny that this is generally one full of beauty throughout the whole of our country. Our poets have sung the beauty and quiet of our English Cottages. Travellers from foreign lands speak of them with unvarying admiration. Painters love to represent their picturesque gables, and shadowing coves, and latticed windows, and broad chimneys. It is some few features of this beauty we would wish to point out.

And first, I would bid you remark how entirely they are designed to harmonize with their particular sites, and with the prevailing features of our quiet English landscape. This implies in their builders a perception of artistic propriety and fitness which is now little understood, and seldom attained, by our modern architects, even in great works. How often in these days do we see a building raised up in narrow streets, yet framed on a design requiring it to be seen from a distance, and fitted for some commanding position in the country. On the other hand we have buildings, like the facade of the new museum of Oxford, fitted for the continuous line of street, standing isolated and alone. Now, this fact of appropriateness to the character of the object of the building, but to the nature of its site; to make it thus appear to belong to the landscape around it; to grow out of it instead of being an extraneous thing, put down, as it were, haphazard, where it is; this, I say, is a mark of subtle and true artistic feeling. It was possessed in an eminent degree by the builders of old time; it is seen in their greatest works. The house of the noble in the city was a different type from that of his mansion in the country. Their churches varied according to the nature of the scenery around them and the materials to be used. Some had spires, some towers—the towers themselves varying in form and size, and yet all so exactly suited to their several situations, that, to a practiced eye and cultivated taste, no small portion of effect could be lost when any two different types interchanged in site. A Pembroke church, with its severe and simple pyramidal tower, would be out of place in the wooded or cultivated plains of Essex. An elaborately tower like that under whose shadow we are sitting, or one of beautiful brickwork like that seen in all se Photo. Heddon would lose half its beauty among the wild hills and rugged valleys of the west. Now just this very principle which the old architects adopted in these their great works, they successfully imparted, even to their smallest. All that we have said of mansions and churches applies equally to their cottages and farms. To a medieval builder nothing was small for care. The same air of grace and fitness that marked the mansion of the squire or the noble was thrown round the humble dwelling of the farmer or the peasant. If one looked grand and noble, with its wide sweep of lawn and far reaching avenues, the other equally became its knot of shadowing elms, and its little village green. The one as well as the other was fitted for its special site, and seemed equally a part and parcel of the general landscape around. Herefordshire we have the homesteads formed with the black beams, showing oftentimes in beautiful and varied patterns through the white plaster between. In Gloucestershire the rich yellow stones with stone mullioned windows and quoin, and roof of slates, give an air of solidity and comfort, fitting the rich gardens and orchards in which they stand. In Wales the grey cottages, low and nestling in some hollow of the hills, give an air of shelter from the wild winds of the mountain; all these, fit and beautiful in their several positions, we feel would be out of place were it not for their form of roof, varied by projecting gables, and covered with thatch or tile, the white walls, with their quaint varieties of pargetting, seem at once the natural outgrowth of our quiet, undulating country, and lend to it one of its greatest charms.

I know, indeed, it may be said that all this is purely accidental—that this grace and fitness result simply of themselves from the accident of material, or what not. But the objection is a shallow one. Things do not grow of themselves into forms of beauty. To make them do so requires knowledge, and thought, and skill. Nay, the objection itself only proves the more what we are stating, for it is the very height of art to conceal itself, and appear simply as the mere natural outgrowth of utility, of necessity, of material.

Take another view of these homesteads of our country, and observe the fitness with which their mere outward form expresses the kind of life for which they are constructed. There is thrown around them an air of quiet, calm repose—they seem to have no material atmosphere surrounding them completely with the quiet, unambitious tenor of a country life. Those, indeed, who know the country best, know that this appearance is but too fallacious—that amid those quiet scenes breathe the same wild human passions; there are yet the same troubles, miseries, the same wayward errors and sins, that beset life in the cottage as elsewhere. Yet the comfort of the cottage, we feel the thought of all this runs counter to the outward show of things, and this very feeling of incongruity shows how deep a hold upon our mind have the ideas of peace and repose that the old builders have impressed upon their buildings.
Yet a third matter to which I would call your attention in these old domestic buildings is their infinite variety. These indeed, if one were to call them by their due name, are the high-pitched roof, the wooden-framed or mullioned windows, the genial stack of brick chimneys, suggesting the warm angle within. But at the same time there is an almost endless variety. Sometimes the roof is unbroken from end to end, sometimes a central gable breaks its line, sometimes there is a gable at one end of the front, sometimes of the wings. When several houses are placed in a row, under one roof, the windows are sometimes dormers, sometimes carried up from the wall in small gables, grouping beautifully with the larger gables which in some cases usually flank on one end or the other; sometimes the upper story projects over the lower, throwing out a balcony which adds greatly to the effect of beauty. The walls, as I have already said, though often simply rough cast, yet frequently present a greater number of patterns in paring, quaint and simple, and eminently constructive in design. All these and other matters we might mention, alone or in combination, produce infinite change and variety of form, and this alone is enough to claim for them a high artistic excellence.

Some houses of period with individual variety is the law of nature’s works; it regulates the growth of the trees of the forest, and the leaves of each individual tree; it marks no less these old cottages and homesteads of our native county.

This, then, is a high artistic feature—it is more, it is a great moral influence. As a rule the affection of the dwellers of these houses around them, to separate them from others, to intensify the idea expressed by our sweet English word Home.

Contrast these ancient houses with those which we erect today. Take an ordinary modern cottage, four square brick walls, a door at one side and a window at the other, and two windows above, a slate roof, low in pitch, with no eaves; it is a disgust—a blot upon the landscape around it. It is impossible to love a base mean thing like that. Or take a modern row of cottages—each one exactly like the others—each a repetition of the type I have described by describing: without a single thing to distinguish one from its neighbors, the houses that are supposed to have how can any affectionate associations gather round such a dwelling as this? It seems almost a profanation to apply it to the sacred name of home. There is certainly nothing in it to attract, and everything to repel. But being constituted as we are, with body as well as spirit, susceptible as is our nature, and especially in its uneducated state, to external influences, it is, to say the least, unwise to render our homes outwardly unlovely and repelling. Our fathers acted wisely as well as tastefully when they sought to render a man’s house itself attractive, to give it an individual peculiarity distinct from any other, and to make it outwardly a fitting type of those fair and gentle influences which so well suit us.

Such are a few of the artistic features of an old homestead—it is a poor and meagre outline; but it may serve, I think, at least to call attention to them, and gain for them an interest which they well merit, and which they but seldom excite. The more you really look at them the more you will be struck with their picturesque beauty. They are, moreover, very precious as memorials of the past of our people, still existing among us, and which if once lost could never be replaced.

And it is a fact that they are, slowly indeed, but surely, fading away from us. The mere process of inevitable decay must rob us of them in time, and of the oldest and of the best first; but besides this one and another of them is falling often before the march of what is called improvement; either altogether pulled down to make room for some vulgar, tasteless erection, deficient in every point in which they excelled, or else mutilated or added to, and all their native beauty destroyed. Now, surely it is to be lamented that these buildings should be permitted to go away in this way. If such were the case, we should be like the bees, if the things themselves must cease from among us, surely at least, their forms may be preserved. Now this is the real object I have had in choosing the subject of this paper. I would venture to press upon you the importance and interest of securing some memorial of these old buildings. In every neighborhood there has been, or has there been the making of some sort of sketch, however rough. Will it not, then, be well to keep an eye upon these old buildings? whenever a house or cottage is to be pulled down, or improved, as the term is, let some one or other make it his business to take a sketch of it from one or two different points of view; a simple outline would be enough, just catching its leading features, the distribution of its shape, and the arrangements of its parts. Nay, more—there are many of you in these days who are photographers. I can conceive nothing more interesting than that some one who possesses this valuable art should go round his own particular neighbourhood and take photographs of the best and most picturesque of these ancient homesteads. A collection of such photographs would have an interest and value almost impossible to over-estimate. They would form at once interesting memorials of the past, and be precious guides to our architects for the buildings of the future. We are never likely to have a type of building so fitted for our climate and scenery as these, and it is surely possible to combine with the increased comfort and greater requirements of modern life these time-honoured forms which add so much of beauty to the hills and plains of our native land.

THE FESTINIOG RAILWAY.

(Concluded from page 224.)

Mr. Tith added that, last summer, Mr. Charles D. Fox inspected the narrow gauge lines in Norway. All the details, with the engines and rolling stock, were unreservedly approved as this dispatch stated he wrote—"With reference to the interesting question of the 3 feet 6 inch gauge, I shall return convinced of the thorough efficiency of such a gauge for the purpose of a new country, and of the wisdom of adopting such a gauge, for the traffic is not so heavy." Mr. Phipps inquired, whether the economy of these narrow gauge lines did not consist chiefly in the diminished cost of construction, rather than in working the traffic of the line? In his opinion, the cost of haulage per ton was not so much. In this the Gentleman from Lancashire expressed himself as favouring the 3 feet 6 inch gauge, and said that it would only be necessary to key the fastening upon the axles, which was obviously done by diminishing the width of gauge. On tolerably level ground, with the ordinary alternations of cutting and embankment, where the slopes formed a large proportion of the whole, it was evident that the saving from narrowing the gauge would probably not be considerable.

Mr. Bruff replied that, though considerable economy in the earthworks arose by adopting sharp and reverse curves on the Norwegian lines, the bridges and viaducts were extremely heavy, so much so, as to have astonished him when he was informed of the prices at which the lines had been carried out. No doubt, the economy of construction was greater than if a heavier rolling stock and permanent way had been employed there.

Mr. Gregory, V.P., remarked that, with the narrow gauge, a shorter wheel base of the engines could be adopted, which gave greater ease in traversing sharp curves.

Mr. Robert Mallet said, as yet no mention had been made of another narrow gauge line, which had been a long time in successful operation, viz., that between Antwerp and Ghent, the gauge of which, he believed, was only 2 feet 3 inches. He could not give the precise particulars of the rolling stock, but could state generally, that the carriages were of the ordinary English design on the Festinioog lines. The subject of narrow gauge lines was not new to him. About eleven years ago he recognised the advantages, in respect of cheap railways and traffic, which would arise from narrow gauge lines; and in 1858, he had proposed to Mr. Heman a line along the north shore of the Bay of Dublin to have a gauge of only 2 feet 6 inches. That project, for reasons it was not necessary then to go into, was not carried out; a bill, however, was presented in the present session of Parliament for a similar line, and he believed that it might be made on the narrow gauge. In viewing the question of narrow gauge and ordinary gauge railways, it was necessary to consider, what he might call the prudential considerations, those that related to the circumstances of traffic, &c., separately from those which were of a technical character. In Sicily, he was late of the Bengal Engineers, and he had had many opportunities of discussing with him what had passed relative to Indian tramways, or branch railways. Colonel Tuley’s opinion was decidedly in favour of narrow gauge, and he contended that in India it was simply a question between the bullock-cart, or these narrow-gauge lines, as feeders to the trunk lines. Reverting now to the purely physical considerations, it ad to him, as a physical necessity that, not only the original cost of two similar lines differing in gauge, but also the cost which would be the ratio of the cube of the length of axle, or what was the same, the breadth of gauge. A little consideration would show that, however starting, this proposition, without having any pretensions to be a mathematical truth, was nevertheless approximately true. As an illustration of this—if the axle of a carriage, as a cylindrical shaft, exposed to cross strains, were taken, it would not admit of dispute, that for equal strength, on different gauges, the diameter must vary as the cube of the length, or of the gauge; therefore the weight of the axles would be in that ratio,
and must be that of the wheels to carry them. Then as to the carriages, as it was evidently undeniable that the weights of any similar structures whatever, as varied as the cubes of their homologous dimensions, so the width of the road, or to be exact, the width of the track, was of equal lateral strength: and the axles and wheels must be proportionate to carry this load. In a word, all the rolling stock would be increased in something like the ratio of the cube of the gauge. If this were so, the cost of the haulage would be absolutely double; the permanent way, it is estimated, would be proportionate to bear that load; and if it were true, that the cost of haulage was a function of the weight drawn, it equally followed, that the rolling expenses, or those for working the line of road, would be about in proportion to the increased weight, and all the other calculated expenses to guard against being mistaken as now speaking mathematically, or as using the cube as a precise expression of the relation; his intention was merely to illustrate the proposition which he deemed generally true—namely, that the cost of any railway, however profitable by the working railways, increased with the width of the gauge, but in a greatly higher ratio, or in other words, that in proportion as the gauge was reduced, both the first cost and the working expenses would be diminished. There were some special physical advantages in narrowing the gauge; for example, engines, or carriages could go round a sharp curve more easily with a 2-feet gauge than with a 7-feet gauge: this fact had had some doubt thrown on it, but its truth was obvious, from the consideration that if the two gauges could be brought close together, or in other words, there would be no longer any resistance to the car in getting round the curve, and the inner wheels having to go over different lengths of curve in equal times.

Mr. Savin said, he had not at first imagined that a line of so narrow a gauge as the Festiniog Railway could be worked successfully with locomotives; but he had travelled on that line both with locomotives and in the boat carriage, and thought it a great success, both in regard to its adaptation to the circumstances of the locality, and in its commercial results. The gauge of the railway was chosen, no one or other to be uniform, as far as through systems of working were concerned; but, having had some experience in Wales, he thought it impracticable to carry out the broad gauge in that country. He had seen various gauges in its course of about 5 feet 6 inches up to 3 feet 6 inches; his own preference was for 2 feet 3 inches or 2 feet 6 inches, where the valleys were crooked and steep sided. In this way many physical difficulties might be avoided, by the adoption of curves of shorter radius; a 2-feet gauge line would contour the curves much more closely, reducing the cost of railway communication to a minimum. A line 16 miles long, for which he had given £20,000, was laid on the gauge of 2 feet 6 inches, and that line had been extended into a district similar to that which the Festiniog Railway of Wales. This had not been a very little chance of carrying a bill for a railway on a gauge of 4 feet 8½ inches in that district, and the result would have been, that, but for this class of railway, the present development of the mineral resources of those valleys would have been delayed. There had been no reference to districts such as this, that the subject was worthy of the fullest consideration on the part of engineers.

Mr. G. R. Bidder—Past President—said he had listened to the paper with great interest. It was an evidence that the Author, as a government official, had a view to the economical development of the country, and that the system was not proposed as a means of economy, in other respects than that there were cases in which the economy of constructing the narrow gauge should be considered, where it could be introduced, for the sake of the curves and gradients, in districts where it could not be introduced. That was the only ground on which this question could be fairly considered; but the Author did not pretend that a narrow gauge could be worked more cheaply than a broad gauge. The arguments adduced in favour of the economy of working the narrow gauge, if followed out, would lead to the conclusion—that if there were no gauge at all, a railway could be worked for nothing. The question was, was the cost of moving a carriage, but at what cost a ton of minerals, or one hundred passengers, or the cost of carrying six hundred tons of coal, a ton of minerals, or a hundred passengers, could not be moved on a narrow gauge more cheaply than on a broad gauge. That was so in this case was shown in the figures given in the paper; for, although the subcommittee of the inauguration of the line were satisfied with the thing to do, yet he did not understand the Author as propounding the question of these narrow gauge railways to show that the cost of working for ton, for passenger, of passenger, was any cheaper than working on a broad gauge. It was not in the Author's definition to render the economy of construction, as compared with the cost and in convenience of trans-shipment. As to these railways, he had no doubt for short horizons, even narrow gauge, lines, it might be useful to them. But in this country this question was not yet introduced. But in this country this question was not yet introduced. The question of the narrow gauge railways, which required very much with such lines. Engineers were allowed to deviate 5 feet vertically in open country, and were restricted to 2 feet in towns. Anything more absurd than that, it was impossible to conceive. In the neighbourhood of London, where the country was flat, a limit of 5 feet might be suitable; but in districts where the inclination of the surface of the ground was so great that it might be necessary to change the work from cutting to embankment; and the 5 feet might require to be 20 feet, or 30 feet. Parliament said “A railway shall not cross a public highway in this country if it interfered with its level, excepting it be by a bridge or a tunnel; but there was no permanent way of avoiding the 30 for a turnpike road; nor shall it cross a road on the level, without permission.” Of course, these were questions of local circumstances: in 20 might be a proper gradient for London; but there were districts where it might be a lesser gradient, or where the traffic might amount to three vehicles, or four vehicles per day. No attention was, however, paid to that fact, nor were reasons listened to—but a gradient of 1 in 20 was insisted on. He had had to say, on one occasion, that the utmost he could do by the author of the project, which could not prove the preamble, for the gradient of the valley 1 in 11, 1 in 20 would go quite across the valley. But what he proposed was, to spend £5000 in improving the road on the other side of the railway, leading to the nearest village, and then the bill was passed.

With regard to level crossings, he feared he had been a great offender, for one line he had as many as thirty-eight level crossings on as many miles of railway. But now the rule was, that there should be no level crossings. In consequence of this, where the Great Eastern Railway crossed a country road at its apex, a most costly place, for a station, especially for mineraux, the Engineer was compelled to avoid making a level crossing, though it was the highest point of the country, and to make that road 15 feet or 10 feet, at a cost he believed to be £30,000, or £25,000. There are no doubt, stations, where the opening of the line was delayed for several months, and the thing was a nuisance to the neighbourhood.

He offered these remarks, because this paper showed, that the Author's most important result was opposite to the results. He said in effect “where the broad gauge is inappropriate have a narrow gauge.” He agreed with him; but the question of commercial consideration entered as much into broad as into the narrow gauge railways, and regard must be had to the local circumstances. In the case of a broad gauge such a narrow gauge would not be great, the principal item being in the additional length of the crossing sleepers. The rails might be lighter than those of the main line, and the engines for working the branches made light in proportion. Six years ago he had constructed 27 miles, and the work was all light, and the crossings would not be great.

Mr. E. Wood thought it was evident, from the observations which had been made, that no one system could be laid down, nor any one gauge be fixed upon, as applicable to all conditions of locality, traffic, and circumstance. What was a workable broad gauge in one country might not be so in another. With regard to the Indian gauge of 6 feet 6 inches, he could quite understand, it was most desirable to construct branch lines on the same gauge as the main lines, and in a flat country like India the difference of cost as between the two gauges of 6 feet 8½ inches and a narrow one gauge would not be great, the principal item being in the additional length of the crossing sleepers. The rails might be lighter than those of the main line, and the engines for working the branches made light in proportion. Six years ago he had constructed 27 miles, and the work was all light, and the crossings would not be great.

The line was situated in the lower range of the Andes, where the gradients were necessarily severe and the curves sharp. Here curves of 500 feet radius in combination with gradients varying 1 in 20 to 1 in 30, constantly occurred. It was said, by the engineer of the country, that the work was done with locomotives, and that it was laid out for mule traffic, and it was worked by mule power for eighteen months. But owing to the seasons, of drought and other causes the expenses of working were so high, that a decision was come to by the writer to let it run, and the rigid structure power. He was called upon to design the engines, and in his design he limited the weight on the driving wheels to 7½ tons, but the difficulty was to get sufficient adhesion to take the loads up the severe inclines of 1 in 20 for 7 miles, and 1 in 30 for 12 miles. That difficulty was overcome by putting 6 driving wheels to the engines, and placing the front end on a bogie truck. The rails of 42 lbs. to the yard, had stood exceedingly well, and up to this time were in good working order, for although the engines had operated so many miles, they had produced no sensible injury to the rails. The ordinary working speed on the inclines was about 12 miles per hour.

From the experience of the working of that line, it was evident that railway construction in countries of this kind might be advantageously worked, if due regard were paid to the adaptation of suitable rolling stock.

Mr. W. Bridges Adams said, in dealing with the question of light railways, these were constructed from which, 27 miles in the commercial, and mechanical. The latter might be a toy, but the former must have reference to utility. The object being to transport materials and men, there must be sufficient volume in the carriages to hold them conveniently. Now, it was not a question of dimensions, and it was necessary to render the passengers to the seats to prevent over-crowding. It was quite true, that the narrower the gauge the shorter might be the distance between the axles, if rigidly parallel, so as to facilitate passing sharp curves; but, on the other hand, the sharper the curves the necessary need of straight lines of way, or very flat curves might now come to rigid, by provision being made for the axles to radiate on curves, and point truly to the centres of those curves. By this arrangement, and the use of
spring tires, permitting the wheels to slip within the tires, it was now practicable for carriages, or engines, with extreme wheels 25 feet apart, to roll without rail friction round curves of 2 chains radius, and this fact rendered the width of gauge whether 2 feet or 7 feet, a matter of indifference as regards curves. On the Norwegian line of 3 feet 6 inches gauge, engines of 2 feet 6 inches were required, although the width of the carriages was another consideration. As a mechanical rule, the carriage bodies might be safely made double the width of the gauge. Beyond that width there would be a tendency to unsteadiness. A 2-foot gauge, by that rule, would only admit a carriage 4 feet wide, and that, if necessary back to back, was very cramped. Again, with passengers so placed, 3 feet in length of the carriages would only carry four passengers. While seated fore and aft, eight passengers could be carried in a 4-feet length of carriage, with a 3 feet gauge of rails, i.e., one-fourth of the broad of train would double the number of passengers, or volume of goods.

With a 2-feet gauge and wheels 2 feet in diameter the boiler and framing should be carried above the wheels altogether. With a gauge of 9 feet 6 inches it might be practicable to construct the frame. With a gauge of only 2 feet 6 in diameter seriously damaged the rails if heavily loaded. If of larger diameter, better adhesion might be attained. The worst gradient on the Festinio line appeared to be 1 to 60, but with heavier gradients and a gauge of 2 feet 6 inches of course, such engines would be unsuited for constructing engines with eight drivers to roll round curves of 2 chains on any gauge. The very important feature in the engine described was the great pressure of steam—200 lbs. to the inch.

There was one reason why it was desirable to make branch lines of a narrower gauge than main lines when the traffic was light, viz., to prevent heavy engines and vehicles from running on and destroying them. But in the coal traffic it was desirable to have as large a gauge as possible, of the greatest capacity and length, capable of running round the sharpest possible curves and up to the pit's mouth, and in this case it was better to have no break of gauge. On a gauge of 4 feet 8½ inches, it was quite practicable to use 8 wheel wagons, 40 feet long, by 9 feet wide, with an interior capacity of 1,000 cubic feet.

Mr. Gregory, V.P., said, he was prepared to recognize the propriety of the measures adopted on the Festinio railway, under circumstances which, he thought, were special and peculiar; but the Institution and the profession in general cannot adopt if the total fall and to them, to adopt, as had been suggested, the idea of a supplementary narrow gauge for all small branch lines. He believed that the advantage of such a gauge was limited to local conditions, such as those described in the paper. This had been particularly the case with respect to the 4 feet 8½ inch gauge already existing in those workings, and the character of the works and the curves of the Festinio railway itself, it would have been exceedingly difficult to adopt the ordinary gauge, therefore the main line had been turned in the most, to make the exceptionally narrow gauge, by converting the main line into a line for general goods and passengers. They also did well to introduce locomotive power on the line; but all who heard the paper must feel that this was done under difficulties. He must record his protest against the theory that the cost of the working expenses of railways was in proportion to the cubes of their width of gauge. The number of goods, or the number of passengers to be carried, was an essential element in such a question, and he trusted with all his power to gain that measure. Pickford could carry on their business more cheaply in commoners' carts than in their usual vans. This illustration would show that such a theory could not be practically supported. He was sure while Mr. England had got work out of an engine, under difficult circumstances, so much of an engine as has been patented, in order to obtain greater power, and more economy for a large amount of work, if he had a wider base to work upon.

In considering the circumstances under which an exceptionally narrow gauge might be adopted, he thought that the same considerations as to chains, or 4 chains, its supposed advantages. Setting aside the idea of any saving in working, when there was anything beyond a very limited traffic, these advantages appeared to be classed principally under two heads, viz., firstly, a saving in cost of construction, and secondly, the decrease in the engine cost, and the increased power. There was no reason why an engine of similar weight (plus a little extra for the longer axles) could not be applied to the ordinary gauge. But it had been asserted, that the weight of the rolling stock was increased as the gauge was increased. An engine of 2 chains could be run on the rails of the Great Western broad-gauge engines should be 34 lbs. Looking at all these
circumstances, it was clear that the national gauge was nearly the best that could have been chosen. On an ordinary road, where there was no limit as to gauge, carriages had a width of about 4 feet 6 inches, and even the smallest cart was wider than 2 feet; he hoped, therefore, that engineers would draw curves that were narrow enough to meet this standard. For reasons which he would state, he was of opinion that it would be most objectionable to attempt to introduce it into the country generally. With respect to the existing broad and narrow gauges, the number of trains on the narrow gauge was as great as on the broad gauge, or rather, that engines could be constructed to take as great weights on the narrow gauge as on the broad gauge; and if engines were made much heavier than the present ones, it was difficult and dear, would receive no reply. But there was one difficulty greater than all the rest. The result of the work of a train was the loads, in unloading, and moving of trucks and carriages from one part of a station to another, across turn-tables or switchers, and any one who had had experience as a station worked upon the mixed gas, must have been struck with the great additional expense in working the broad-gauge plant at the stations. It was not difficult for a couple of men to move a narrow-gauge truck or carriage to any part of the station without shifting the broad-gauge plant at all. It was the conclusion that, from 8 tons to 9 tons, for trucks was the maximum load that should be carried on the narrow gauge, with a due regard to economy and safety. If that weight for the load was exceeded, the weight was comparatively so much more than the weight of the truck, and the train would be considerably increased, causing bumpy axles and other objectionable results, so that it was not uncommon to see heavy wagons standing under their load, at various sidings and stations, and waiting to be repaired. On the broad gauge, there was no such thing. The result of this was 17,000 was placed under trucks at work; for a long time the capacity of these trucks was limited to 6 tons; now the capacity had been increased to 8 tons; but the Company did not approve of greater capacity than that. He was of opinion that the economical purpose of the gauge was to be suited to the best, and superior to either the broad, or the narrow gauge. But there was another important consideration: if a very narrow gauge were adopted, it could only be on branches connected with main lines. That would involve, in all cases, trans-shipment of passengers, goods, and coal, at the junctions; and, in itself, it would cause a greater amount of expense than the interest upon the increased first cost of the line upon the uniform gauge of the parent lines, both in the purchase of land, and the construction of rolling stock. That was a fatal objection to the introduction of a very narrow-gauge line with which the branches were connected. He had no doubt that in a very few years the gauge of 4 feet 8½ inches, as being the best adapted to the commercial wants of this country, would be the only one in use.

Mr. John L. Colburn asked whether the question, how small could a locomotive be made to give practically useful work? In 1842, he was the contractor for a portion of the works on the Great Western Railway of Canada employed the steam excursions, which no doubt many present had seen, but which he considered not nearly large enough. The width of the 12 feet gauge was an inch and a half. Mr. Colburn designed and built a small 4-wheel truck engine for working these wagons, and the other similar engines were afterwards built. The tank was placed under the boiler between the frames, and as the gauge was so narrow, the fire-box was placed behind the driving wheels, and to correct the superheating weight the tank was carried as far forward as possible. The engines were of sufficient size with fuel and water so that they could be run on a branch line, and the weight of the 4-wheel truck engine, placed on 4 feet 6 inches apart from the centre. The engines worked well, although of course only at moderate speeds.

Mr. James Brunel knew the Festiniog railway well, and though he did not know of the working locomotives on so narrow a gauge mechanistically, he much doubted its suitability commercially. On the other hand, he believed that, beyond a certain limit, the wider the gauge, the less would be the dividends: he looked upon that as an established fact. Some years ago he constructed a narrow-gauge line from Portmadoc to Hardnog, in which the track was 4 feet 6 inches, and the total rise in the 8 miles was 900 feet, and the cost per mile, including land, was £2,000: the steepest curve had a radius of 400 feet and the down loads were worked entirely by gravitation; but passengers were not carried on the line; and although he had advised this line to be made on a narrow gauge, he was not prepared to recommend its further adoption, unless for exceptional purposes, or for purposes similar to the one in question. The want of uniformity of gauge was a great drawback to traffic in many parts of this country, and hence any departure from the ordinary gauge would perpetuate and augment that drawback.

Mr. Galbraith said, there was one principle involved in the paper which he had been lost in discussing. That was—there was no room in this country, particularly in the agricultural districts, for cheaply constructed railways on the gauge of 4 feet 8½ inches. He thought there was. There were many cases where, by adopting the 4 feet 8½ inch gauge, the construction of the engines and level crossings at public roads, a railway might be laid down for £4,000 or £5,000 per mile, which would pay a fair dividend upon the outlay; and he hoped it would be encouraged upon the members of the Board to let it be known that the gauge was 4 feet 8½ inches, and if the traffic was of sufficient light, they ought to relax the stringent requirements with respect to expensive permanent way, and costly works to avoid level crossings. He had been engaged in laying out a line in Devonshire, of the gauge of 5 feet, and he had supposed it would be necessary to put down every 500 yards a line at least 15 feet deep, in order to be level. He encountered it, it was impossible that the line could be constructed to pay a dividend at all. In parts of Devonshire there were small public roads, the traffic on which did not exceed two vehicles or three vehicles per day. To maintain, at a heavy cost, the principal of avoiding level crossings in such cases was, he thought, unwise. In many cases, railway companies erected cottages along the line for the plate-layers to be near their work; and there could be no objection to the wires of the men gauging at the same time he had previously accepted a railway for living rent free. He thought curves of 10 or 12 chains radius, and level crossings where the public traffic was light, might be fairly admitted on branch lines, which, when constructed at £4,000 or £5,000 a mile, might be made to pay a dividend. In such cases, a light rail of 60 lbs. or 60 lbs. When a line was constructed, he thought it ought not to be lost sight of, and which was well worthy of consideration.

Mr. Peter Barlow said, that though he was not of opinion that the gauge of 2 feet was expedient, or that any gauge at all approaching it would be practicable, he thought it was time that the society should be united to each other, with the exception of the narrow gauges. He thought the question having been raised, it might not be lost sight of, and which was well worthy of consideration.

Mr. Barlow suggested the question, how small could an engine be made to give practically useful work? In 1842, he was the contractor for a portion of the works on the Great Western Railway of Canada employed the steam excursion wagons, which, however, many present had seen, but which he considered not nearly large enough. He thought that the gauge adopted in this country was the correct one; and in most parts of Canada he had met with nothing but the narrow gauge: with one exception—where the line was worked by horse-power.

Mr. Robert Mallett begged to offer one or two observations in explanation of the paper. He had not attempted to make the gauge the choice dependent upon the purely physical considerations he had brought forward, but, on the contrary, that the choice of gauge must depend largely upon the prudent conditions, and, amongst other things, primarily upon the length of the trusses. In most parts of England, he had thought the institution was much indebted to the Author for having brought the subject forward.

Sir Cusack Honyey had seen the gauges of Canada and the United States and travelled upon continental lines in various parts of Europe. He had no doubt that they were of the opinion that the broad gauge was much more suitable for the traffic. He thought that the gauge adopted in this country was the correct one; and in most parts of Canada he had met with nothing but the narrow gauge: with one exception—where the line was worked by horse-power.
the edge of the casting, added to which it was filled up with tar with which the boiler had been coated. There may be others in a similar condition for which this may be a caution. All mountings, instead of being bolted to boilers, should be attached with suitable fitting blocks riveted to the shell.

"Deficiency of Water."—This arose at night time when the fires were banked up, from the attendants omitting to close the feed stop valve, there being no self-acting back-pressure valve, and the feed inlet being below the furnace crowns. The importance of every boiler being fitted with a good self-acting feed back-pressure valve, as well as of the feed inlet being above the level of the furnace crowns, has been frequently pointed out in previous reports. The furnace crown was fitted with one of those fusible plugs in which the alloy is in the shape of a washer about the size of a penny-piece, having a copper button in the centre of it. This did not, however, prevent the plates becoming red-hot. The plug did not burst out the fire-box. From speaking, go off at all. A little piece of the alloy melted away on one side and allowed a slight escape of steam, which fortunately attracted the attention of a workman, who at once examined the boiler and found the furnace crown red-hot.

**Table of Statement of Explosions from June 23, to July 27, 1886, inclusive.**

<table>
<thead>
<tr>
<th>Progressive No. for 1886</th>
<th>Date</th>
<th>General description of boiler</th>
<th>Persons killed</th>
<th>Persons injured</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>July 2</td>
<td>Plain cylindrical egg-ended</td>
<td>4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>34</td>
<td>July 16</td>
<td>Particulars not yet fully ascertained</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>5</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>

"No. 33 explosion occurred at a colliery at half-past three o'clock on the morning of Monday, July 2nd, and resulted in the loss of four lives."

The boiler, which was not under the inspection of this association, was of the plain cylindrical externally-fired class, its length being 30 feet, its diameter 6 feet, and the thickness of the plates three-eighths of an inch, while the pressure at which the fires were kept was 160. Its data found from the evidence given at the inquest it appeared that the boiler was nine years old, was set with a wheel flue, fed with hot water, and had been cleaned and repaired, when five new plates were put in, but a week before it burst. Also that at the time of the explosion the boiler had plenty of water in it, and that the pressure of the steam did not exceed 27 lb. on the square inch; while, on subsequent examination, the plates were found to be of good quality, and to present no evidence either of flaws or of having been over-heated. The engineer to the colliery, who stated that he had held the position for sixteen years, was very well acquainted to boilers, and had the superintendence of all the engineers, gave it in evidence that it was certain that he could not in any way account for the explosion, and thought that there must have been something more powerful than steam to produce it. The jury brought in a verdict that the four lives were lost by the explosion of a boiler at the colliery, but what caused the explosion there was no evidence to show.

"Such evidence and such verdicts, though but too common, are not only unsatisfactory but positively mischievous, and can only tend to perpetuate explosions, as is shown by the occurrence of the one under consideration. But five weeks before a very similar explosion occurred to another colliery boiler belonging to the proprietor of the colliery, before the same engineer; while at the inquest evidence to the same effect as that just described was given by the superintending engineer, the smith who had repaired the boiler, and the engineman, all of whom considered the bursting of the boiler to be unaccountable, so that the jury gave it in their verdict, that 'what caused the explosion there was no evidence to show.' The tendency of such evidence and verdicts to reproduce rather than to prevent these disasters was pointed out in a previous report in the remarks on this explosion, which ranks as No. 24 for the present year, though it was hardly expected that they would be corroborated by a second explosion at the same works within the short space of two weeks.

"As long as explosions are considered to be altogether unaccountable by those who have charge of the boilers, and this view is indorsed at coroner's inquests, it will be seen that nothing is done for their prevention, and boilers similarly dangerous to
those which have exploded will be worked on till other explosions occur and more lives are lost, when at the inquests the same stereotyped evidence will in all probability be repeated, with the same gloomy and273 -end results. No. 17 explosion was a much more disastrous event than either of the preceding, resulting in the death of five persons, as well as in injury to five others, occurred at ten minutes past six o'clock on the evening of Wednesday, April 4th, at a tin-plate works. In this instance not only did the tube collapse, but both ends of the boiler were completely torn away, and a considerable portion of the furnace tube in another, while the buildings of the works were seriously damaged, the roofs dismantled, and the whole thrown into utter confusion. The length of the boiler was 20 ft., the diameter of the shell 7 ft., and of the furnace tube 4 ft., while the plates were seven-sixteenths of an inch in thickness, and the pressure of the steam 40 lb. per square inch. This pressure, in the absence of any strengthening rings, was excessive for such a tube, and more particularly so if at all out of the circular shape, which is generally the case in those of so large a diameter, unless of first-class workmanship, which could hardly be expected to be met with in a boiler made in the locality in which this one was.

"At the inquest some rather curious views were expressed. An application to the Board of Trade for a government inspector to assist in the investigation had met with a refusal. Coupled with the suggestion that the coroner should, if he considered it necessary, appoint some other qualified engineer in the neighbourhood. This, however, the coroner stated, for the information of his fellow jurors, that a furnace tube of a boiler withstood the same pressure of steam as the shell, if only half its diameter and made of the same thickness of plate; and as in the boiler under consideration the tube a little exceeded half the diameter of the shell it was somewhat weaker, but that had nothing to do with the explosion. It need scarcely be said that this rule is as empirical as it is false and dangerous. Another jurymen undertook to estimate the precise percentage of strength that furnace tubes lost from being overheated from shortness of water; while in the opinion of a third juror, if the plates became overheated the steam would oxidise the iron and blow up the boiler. The coroner stated that it was clear the explosion had arisen from neglect in one or two ways, either in generating too much steam or giving the boiler too little water, but no one pointed out that the explosion arose from the weakness of the furnace tube, or called attention to the fatal defect in its construction of omitting strengthening rings, &c. The jury returned a verdict of "The boiler exploded by some cause or causes unknown."

"The boiler was of the single flue internally-fired Cornish class, its length being 30 ft. 8 in., its diameter 6 ft. 8 in. in the shell, and 4 ft. in the furnace tube, some of the plates of which were seven-sixteenths of an inch in thickness. There were two safety valves on the boiler loaded to a pressure of 40 lb. on the square inch, one glass water gauge, and two gauge taps. The internal flue tube collapsed from one end to the other, with the exception of about 4 ft. at the front end over the fire, which part was quite undamaged. The boiler was at the moment of the explosion the engine was standing, and had been doing so for twenty minutes, the dampers being shut, and the steam it is reported blowing off gently; while the attendant, who is stated to be a trustworthy and perfectly competent work-
man, says that when the engine stopped there were 9in. of water in the glass; and, also, that he tried the top gauge tap.

"A good deal of discussion has arisen as to the cause of this explosion, and it has been attributed, as usual, to shortness of water. Had this been the case, the plates of the furnace crown immediately over the fire would have been the first to have given way, whereas, as already stated, the tube failed at the back end, and retained its original shape at the front, added to which the tube was of such dimensions that it could not be prudently worked at so high a pressure as it was, so that it is thought there is no reason to doubt that the explosion arose from weakness of the internal flue tube, and not from shortness of water. It must not be forgotten that, when an engine is of standing and the safety valves are blowing off, as was the case in the present instance, that the steam pressure will always exceed the load on the safety valves more or less, and it must again be repeated that it has a most important influence on the strength of internal flue tubes, whether they be truly circular or not; which is a consideration too much lost sight of, while it explains the apparent anomaly of one boiler exploding and another of similar dimensions working safely. Tubes made with plates overlapping can never be truly circular. Many of those now under inspection are made without any lap at all, and the ends being welded together, will at least be capable of being used as a sort of rivet. With this arrangement plates three-eighths of an inch in thickness, instead of those seven-sixteenths or half an inch, are found to be ample, and to be perfectly safe at a pressure of 60 lb. per square inch or even higher. Here an arrangement adopted in the present instance the explosion would not have happened.

"It is feared that in the district in which this explosion occurred many boilers of very similar proportions are at work, and under these circumstances it is no kindness to the steam user and to the greater public. It is a case that must be referred to our Superintendents of Inspectors of factory and mill work. It must, therefore, be distinctly stated that all such boilers are dangerous, that they should be immediately stopped and the furnace tubes strengthened. This, in some cases, may be done in places by the addition of angle iron hoops; while in others, where the furnace tubes are much out of the circular shape, it might be better to remove them altogether.

ON THE SCULPTURE IN WESTMINSTER ABBEY,

BY PROFESSOR WESTMACOTT, R.A.

(Concluded from page 220.)

I will now refer to some of those productions which claim attention for their art qualities as they exhibit when they are employed to embellish the architecture and ornament of a building. This is in illustrating scenes in Scripture and in the history of the Church, and it then comes under the class of "subject" sculpture. Though there are works in the Abbey of an earlier date than those now to be brought under notice, there are none of greater interest, in their way, than the series of stone reliefs which decorate the screen on the west side of the chapel of Edward the Confessor. They comprise a variety of subjects, real and imaginative, in the life of that pious monarch, derived from a chronicle written by Alfred, an ecclesiastic of the time of Henry II. This record was presented by its author to that prince in the year 1163, when, after his canonization, the remains of the Confessor were removed to the shrine. The subjects are fourteen in number, and they are separated from each other by trefoils, rudely formed by a running ribbon. The whole length of the sculpture is 38 ft. 6in., by 3 ft. in height. The principal figures are about 1 ft. high. The relief is very bold, the irregular concave ground being much hollowed out behind. There is no evidence of an assistant in setting down the compositions, or even of the date of the curious work; and it is from circumstances only, connected with other erections in this part of the Abbey, that any probable conclusion can be arrived at. It is now generally attributed to some time in the reign of Henry VI. in the fifteenth century. It was not later than this, and reasons might be adduced for giving it a somewhat earlier date. This, however, is not a matter of any great importance; for the few years only, of less or greater antiquity, would not materially affect the interest that attaches to the work; and this consists rather in its being "subject," or illustrative, sculpture than in any merit it possesses as a work of art. The execution is extremely rude. The figures are short and thick, ill proportioned, and utterly deficient in anatomical correctness. Of course it is impossible to judge of the expression, as the surface is everywhere scored and injured by the chisel, and all the lines of the faces are given in the most primitive and clumsy manner. This frieze, which in its time, must have been considered a production of no slight pretension, both from the position it occupies, and the subject treated, shows the very low condition of art in England, at fourteen centuries after Christ. So far from exhibiting anything of beauty or dignity, it is altogether a relic of retrogression; for it is, in every respect, inferior in art-qualities to sculpture near it, of a much earlier date. It is curious to see how little care was paid to what may be called keeping in these designs. In two of the subjects a church is represented; one refers to a miracle operated on an occasion of the king receiving the sacrament, when, it is recorded, the water was converted into the figure of a boy, who gave his benediction to the Confessor and his attendant. The other is said to represent the dedication, by himself, of Edward the Confessor's church. In both instances the church is in a style of very advanced Gothic which has been adopted to give a likeness of the original church. Although these works can take no rank as good art they have an interest of another kind. They are valuable as illustrations of the condition of art; but they have a further claim to attention as exhibiting the tone of feeling of the time. The traditions of the holy life and experiences of the Confessor were thoroughly blended with art for the purpose of giving expression to ideas that were familiar and dear to popular feeling. Without entering into the measure of truth attaching to Abbot Alured's chronicle, sculpture is here employed in one of its most legitimate functions, especially, as in this case, in association with a sacred edifice. Rude and incomplete as it is, this work may justly be referred to as an exponent of subjects of similar importance and character might be effectively and advantageously presented in the decoration of Christian churches.

In another part of the Abbey, between this (Henry VII.'s) chapel, and the chapel of the kings, as it is called, is another very interesting work of a somewhat similar character, though that is in it is more complete. This is the life of Henry V. The decoration consists chiefly of statues in niches, but there are groups of figures in two compartments, which come legitimately within the category of subjects. One is a coronation, comprising several figures, with the king seated in the centre. It is right that attention should be directed to their treatment. That on the right is by far the best, and above all the sculpture is extremely rude, and exhibits no true feeling for art. In other parts of the church—for instance, in some spandrels of the chapel of St. John—there are also examples of what may be classed as subject-sculpture (as distinguished from mere architectural decoration), which opinion, owing to the injury to the surface of the work, but beyond their use in filling in and enriching the space occupied by them, they evidently have but little claim to attention.
The Civil Engineer and Architect's Journal.

September 1, 1865

There is a class of subject-sculpture especially associated with what may be called ecclesiastical decoration, which may not be entirely overlooked in this paper. Strange to say, it is only found in religious buildings; and yet it is usually a character that renders it quite unfitted for such application. This is in the incidents chosen for the ornaments of stall-seats and brackets, and especially in gargoyles and drip-stones, where the meanness that existed between the regular and the secular clergy was shown in the grotesque and often highly indeclicate carvings in which one body satirized the other. It is difficult to understand how the representation of such coarse buffoonery, and even of the most scandalous subjects could be permitted by those who controlled church decoration; at a time, too, when so many years of medievalism, with its emphasis on exemplary religious and pious impulse directed all art. It is thus briefly referred to in this place as a part of our subject, and because Westminster Abbey is not without examples of this strange and lamentable offence against propriety and good taste. It may be added, however, that with very few exceptions, the instances found here are rather of the broadly humorous than of the indecent type.

Before closing this subject, the attention of the meeting may be directed to the very remarkable series of statues that are found in the chapel of Henry VII. Here, indeed, may be seen works that, in certain qualities, may challenge comparison with the finest in any school of the kind. The best of them are fine examples of the success of the medieval artists in treating drapery, and in the impressive simplicity of pose, in single figures. At the same time, they preserve all the distinctive characteristics of the Gothic school, so carefully and so curiously maintained during the whole period of its existence.

The works referred to constitute one of the most imposing of this exquisite architectural triumph of the sixteenth century. The nave of the chapel is divided from the aisles by four arches on each side, and similar arches divide it from five small chapels at the east end. Immediately under the arches, and extending entirely round the chapel, is a range of demi-angels, crowned, in high relief. They are rather grandly treated; some are draped, some are represented with their bodies wadded; and, generally, they have rich, curly hair. Their function is to support, on shields, the royal devices of Henry VII.—the rose, porcullis, fleur de lis, &c. Over these angels are octagonal pedestals and niches, enriched with tracery and foliage, containing statues about 3 ft. high of saints, martyrs, and other venerable persons. There is here great variety of action and a fine feeling for art. The drapery especially are largely and grandly arranged. In the heads, also, there will be observed a remarkable attention to the proper expression, as well as to character and form. The angels of this chapel are, in almost every respect, studied and noble. When the naked form is introduced, as in the St. Sebastian, it is conventional, and as usual shows no intimate acquaintance with the study of nature; but in all other respects these works possess merits of a very high class, and have justly been noticed by all the best judges of sculpture as examples, of the kind, in their head, and in one high degree of study and imitation. It may be noticed that though the statues in the nave average about 3 ft. in height, those in the chapels are nearly life size. They are arranged in threes, over five demi-angels. It is to be lamented that some of these interesting works have been injured, while some have been removed, and the niches and paneling designed for more into the houses of two ducal houses of Buckingham; of the respective families of Villiers, and Sheffield. The statues, of all sizes, employed in the enrichment of the chapel of Henry VII., are said to have amounted, originally, to nearly three thousand. Many of the smaller ones, especially those in gilt metal, have, no doubt, been stolen.

The Monuments.

The earliest examples of sculpture in the Abbey Church of Westminster—and they are believed to be the oldest monuments in England—have been on some tombs in the well cloister. They are of abbots of the church. One of these is said to be of Vitalis, who died about 1082. Two others are of Crispinus, about 1114, and Laurentius, who died towards the end of that century. The effigies of these dignitaries, carved on gravestones, are represented in their robes. That of Vitalis has a long hair; he is bearded, and is one with the remains of a pastoral staff. The execution of these works is extremely rude, and the relief very flat. They possess considerable antique interest, but they offer no peculiarities to arrest the attention of the lover of art.

It may be observed here, that all the earlier monuments in which effigies appear are of ecclesiastics. This may, at first, appear strange, when it would seem to be so much more natural and fitting that crowned heads, kings and queens, princes, or great nobles and knights, should be so honoured, and not that such distinction should have been exclusively confined on the clergy. But here is seen one of the great uses of monumental art, when it is exercised under a real and true impulse: it shows the character of its age. The earliest Christian art, resembling in this impulse all the early monuments of sculpture, was eminently in illustrating subjects of religious interest; and when applied as decoration on the tombs of holy persons or martyrs—prior to the representation of the deceased in an effigy—the subjects of the designs, whether paintings or sculpture, were always taken from Scripture or from some sacred tradition. The character of the art was due to the example of the religious scholars of the debased Roman schools being adapted to Christian illustration,—a new meaning being given them to fit them for this appropriation; but, however expressed, the motive was undoubtedly religious, and such decoration was felt to be the only proper accessory on the tombs of departed Christians. At first no other or secular element was prominently put forth in such works.

The cause of a change in this treatment as applied to monuments is not difficult of explanation.

In the eleventh century, the period when the effigies of the deceased was first introduced, the cloth was executed a very great power, but only spiritual, but politico. Its dignitaries held many of the highest offices of State, and the clergy generally occupied the influential position to which their education and attainments—great indeed, compared with the universal ignorance of the laty of all ranks—justly entitled them. It is not, therefore, necessarily that most of their members should, on their decease, receive marks of honour at the hands of their brethren, especially, too, when these could be conferred upon them in the very edifices in which they had held the highest offices. There was, also, a great esprit de corps in the members of each foundation. Such memorials testified, in the first instance, to the importance of the religious house, while the tomb of its bishop or abbot attracted attention, invited the devotion of the pious, and procured for the church itself many substantial advantages in the way of privileges and offerings from all classes of persons who frequented them, according to their position and means. It must also be borne in mind that the members of the order were entirely and exclusively under the guardianship of the clergy. Ecclesiastics alone controlled everything connected with the arrangements within the building. In some societies, it is well known, their own members were competent to act as architects, painters, and carvers, and often were the sole artists employed in the design and the decoration of the church, or monastery, or whatever it might be. It follows from this, that in erecting monuments of especial honour, the members or chapter of a religious house would, naturally, first pay this mark of distinction to one of their own body; and thus the bishop or abbot, or other high dignitary connected with the particular church would, when the practice of personal representation was in vogue, have all dignity placed over his grave. For a hundred years and more this character of tomb-monument seems to have prevailed. There is not an instance of even a royal effigy during this period, the first regal monument which is found in England so treated, being that of King John, in Worcester Cathedral. Its date is probably early in the thirteenth century, as John died in 1216.

Though the previous strictly religious character of monumental sculpture, admitting only Scripture or sacred subjects in the accessories, was, as has been shown, invaded when the effigy of the deceased was represented, there still was a solemnity and propriety in the design of such works peculiarly appropriate to their nature and character, a propriety which is our chief memorial. The figure was represented recumbent, as though extended on his deathbed. Habited usually in the full costume of his rank, with his crozier or pastoral staff by his side, the chalice in his hand, or sometimes with the hands in the action of prayer, the bishop or abbot, or whatever his title, appeared simply as the dead or dying Christian priest. It was a record, a memorial of
the individual—no more. There was no ostentations display of worldly distinction and titles, no nouveau riche envy. The name only—and sometimes not even that—with a date, was inscribed round the margin of the stone, and this was followed, occasionally, by a simple petition for divine mercy, or asking the prayers of the passers-by.

The principle which is so conspicuously exhibited in these earlier works continued to influence the monumental design when, subsequently, such memorials ceased to be confined to the clergy, and were erected to the noble and distinguished among the laity. The recumbent effigy of the deceased surmounted the tomb. The attitude was still extremely simple, and in perfect repose, excepting when the slight action of the hands, raised on the breast, indicated that the figure had been occupied in its last earthly moments. Whether the figure was that of a prince, knight, or lady, it was dressed in the costume of the day; and it gives great antiquarian interest to these monuments to have the assurance that the effigies on them really represent the individuals whom they record in the dresses worn at their respective dates. In a number of instances in which tombs have been opened, the costume in which the deceased was buried has been found to correspond with that given to the sculptured figure. The monument before alluded to of King John, at Worcester, was examined late in the last century, and, allowing for the changes consequent upon its great age, the dress in which it was once博览会, appears to be clearly identical in its forms with that sculptured in the effigy.

The first regal monument in Westminster Abbey, in point of date, and having an effigy on it, is that of the founder of the present edifice, Henry III, who died in 1272-3. The tomb was erected a few years later by his son and successor, King Edward I, and is a kind of representation of the number of the members crowded, habitated in royal costume, with a mantle reaching to the feet. The head, with its crown of fleur de lis, rests on two small pillows. The long curls of hair fall from under this coronet; and the face, which appears small and delicate, is no doubt, a portrait, with a beard and moustaches. The action of the hands suggests that the figure may originally have held some object, probably sceptres, no longer remaining. The feet have shoes on them, enriched with a running pattern of diaper gilt. As late as 1681 there was a lion against which the feet rested. This has disappeared, as well as some architectural decoration over the tomb. The material of this extremely interesting statue is marble; and it is thought by some that many of the members, however, mention his authority, that it was considered the first example of metal casting in England. Both the statue and the table beneath are richly gilt, but the hard coating of dirt that has been suffered to accumulate over it entirely conceals this decoration. The latter is diapered with lozenges, each enclosing a lion rampant, and this ornament has been gilded, but not finished near the pillows. There is great dignity in the simple pose of this statue, and the drapery is very gracefully composed. The workmanship and materials throughout are remarkable.

The panels at the sides of the tomb are of polished porphyry, surrounded by a border or framework of mosaic, with gilding and coloured stones. At each corner there are twisted columns, similarly enriched with variously coloured marbles. The lower portion, or base of the monument, still exhibits the signs of its former lavish enrichment, in its lozenges of green jasper, and the remains of elaborate ornamental carving. It is said that Edward had the stones employed in its decoration brought from France in 1281.

There is a peculiarity in the base of this tomb, which is worthy of remark. On the south side—that within the chapel—are three sunk compartments. The centre one has a pediment supported by pilasters, with an architrave. The side recesses have, in each case, a small toescreen. It is curious to find that these recesses were used as "ambies" or lockers, in which sacred vestments or other objects, and possibly relics, were kept. At the back of each is a cross in mosaic. It will be observed that the style of architecture exhibited in this work is of a very mixed character, and is highly suggestive of a foreign origin. It is known that the Pietro Cavallini, who had a workshop in Westminster Abbey, and as well as that of Queen Eleanor, and it is not improbable that this may fully account for the non-Gothic treatment of the architectural portions of the design.

The immediately adjoining tomb, also, in the Chapel of the Confessor, merits attention for the extraordinary elegance and beauty displayed in some of its details. It is that of Eleanor, the wife of Edward I. She died in 1291. The figure is recumbent, habited in the royal costume. The hands are adorned with the utmost grace, and there is a calm, gentle expression in the face, which is extremely touching. There has been a question as to the authorship of this very beautiful work, as well as the monument and statue of Henry III., and a patriotic desire has been shown to attribute them to native artists, but other and Flaxman's name has been put forward. It is, however, probable that important parts of these designs, especially in the figures, is in the general inferiority of those decorative portions which would necessarily be executed by such workmen as could commonly and easily be found in this country; and the mention of Pietro Cavallini in a contemporary work gives strength to this opinion. This is a subject of very great interest to Englishmen, but it is not possible at this time to give it the consideration due to it. The occurrence of unquestionably English names in the documents connected with public works proves the existence of native artists; and it is natural that art-historians should endeavour to show that some of the most interesting works of art were produced by English artists. In Southwell Minster, at Wells, there certainly is no appearance of foreign interference.

They are as original in style as they are rude in execution.

The next monuments especially worthy of remark for their sculpture, are in memory of King Edward III., his Queen Philippa, and two of their children. This king died in 1377. The royal effigy, of bronze, lies on a table of black marble, and the whole has been richly gilt. In this statue there is evidence of great care in the portraiture of the deceased monarch. The face is long, and there is a remarkable fall in the lower lip. The hair is also, doubtless, represented as worn by the king. It is long and slightly curly, and the beard is ample and flowing. Altogether it is an interesting example of attention to nature, in transmitting the likeness to posterity of one of England's greatest sovereigns. There are at the same time those conventionalisms of treatment which, while they give its character to Gothic art, remove the works out of the category of really good sculpture. The long drapery in which the King is habited, though extending to the feet, shows that many of the folds and the fall of the folds. They are composed, in straight parallel lines, as if the figure were standing. Among the careful details the shoes are "rights and lefts," erroneously believed to be a very modern fashion of shoemaking. This tomb has suffered greatly from age, neglect, and no doubt intentional illusiveness. Much of the material has been removed, and the small statues that decorated the tomb have been stolen. Some of these representing the sons and daughters of Edward were in solid brass gilt.

The tomb of Queen Philippa, the consort of Edward III., still shows proofs of its former magnificence, though it is marked by the most injured of the monuments in the Abbey. The effigy of this princess happily remains in a condition to afford a good idea of her person, as well as of the art of the day. The portrait is evidently carefully studied, and the sculptor who was able to give so much natural character in the treatment of the details was no mean practitioner. Such a practice on the part of artists of widely different schools who employed in these productions, though it will be seen they were still under the influence of a peculiar mode or style which makes all, even the best, of Gothic sculpture. The cost of this effigy gives great antiquarian value to this monument of Queen Philippa. It is a small statue, and may be seen in the north transept of St. Edmund's, which may here be noticed, on which repose two very small alabaster figures of children of the above king and queen. They represent William of Windsor and Blanche. This interesting memorial of these young persons stands near the fine monument of John of Elytham. It has been much damaged, and the head is off. The Pietro Cavallini, who had a workshop in Westminster Abbey, and...
apostles, saints, or other persons, to enrich the sides of the tomb or the architecture connected with it. The angels appear ministering, sometimes at the head of the figure, on each side of the pillow, sometimes at the feet. They usually are represented kneeling, or at the feet, in the attitude known as 'towards', throwing incense from censers. They are less frequently seen at the feet, where either a lion or a goat, sometimes both, couchant, are made to support the feet of the effigy. With respect to technical treatment, considerable improvement will here be observed in the graceful manner in which certain details are represented. The draperies of the figures are frequently arranged in an artistic and rich style of monuments of their time. The precise date of their erection is not known, but from the general treatment, the costume, and the architectural details, they may probably all be placed at between the middle of the reign of Edward I. and the beginning of that of Edward III. There is also so much similarity in the general design and details that it has been supposed that the same artists were employed on all the three works.

Crouchback died in 1296. His effigy lies on an altar-tomb.

He is clad in chain-mail, and wears a close round helmet. The figure is slightly turned to the right,—a movement that may have been intended to convey the idea of looking towards the altar. This monument exhibits the peculiar embellishment that began at this period to characterize these designs. The sides of the tomb are filled with small figures in niches, under canopies; and the different portions of the lofty canopy which surmounts the whole work abound with decorative details. In the large trefoils, in the apex or pediment, are figures of the earl on horseback, armed in mail. The whole was gorgeously coloured and gilt, and remains of this may still be discovered in some parts of the monument.

The monument of Aveline, his wife, the daughter and heiress of William de Fortibus, earl of Albermarle, consists of an altar-tomb, upon which, under an elevated canopy, reposes a recumbent effigy of this last of the last of the castle's supporters. The effigy is made of alabaster; and the details, of plate-armour, surcoat, gorget, coronetted helmet, with the other proper accessories, give great antiquarian interest to this work. The corona is of the ducal form, having alternately small and large trefoil leaves; and it is thought that this is the earliest authority for its being so represented. There is nothing unusual in the style of art exhibited in the sculpture; but with the small attendant angels at the head, and the figures in niches on the side of the tomb, it affords another of the numerous valuable examples of the monumental style of the fourteenth century. There was formerly a very beautiful canopy over this tomb, but it is now very low, and no records remain of it. The overall statues are much broken, and many portions of the monument have doubtless been stolen.

The introduction of knights fully armed and mounted, representing no doubt the noble persons whose larger effigies are placed on the tombs of the earls of Pembroke, is the only instance in this church of a reference to the worldly deeds or occupation of the subjects of the memorial. There are examples in equally early works in other places of a deviation from this rule of confining the accessories to religious objects only, as angels and attendants, sometimes relations, but more frequently ecclesiastics, but none occur here except in the slight degree referred to. Nor is there any example of the double representation of the subject; first, in the figure on the tomb, inhabited in the usual costume; and, secondly, showing the corruption and decay of the body in death; either with the skin shrivelled on the bone, or, as in this instance, covered with a plate of metal over the whole body.

These characteristic examples, selected from the large number of interesting monuments of the Gothic or Medieval school of art, are sufficient to convey a notion of the best monumental sculpture prevailing in what has been thought by many the best period of Gothic architecture. Judged as productions of the rising art, they are very rare, and the excellence of the workmanship is such that the remains of sculpture of a much older date show the art was capable of attaining. They have, however, their own peculiar merit, arising out of the sentiment which pervades them, and the propriety of their design; as expressive of certain feelings, and for its appropriateness, both to place and object. There is a truly serious and religious character in the motive of these works, which subdues and tranquillizes the feelings of those who contemplate them, carrying the reflections of the thoughtful to objects beyond the present. In this respect, how-
ever deficient they may be in technical qualities, they fulfil a
great purpose, and they stamp the monumental design of the
fourteenth and fifteenth centuries with a principle which must
be admitted to be of high value, and worthy of praise and imi-
tation. The term "design" is associated with the statues of the
men of the immediately following dates after those already
particularised; but it may be observed, in support of remarks
already made, that the subsequent monuments were not proofs
of progress in sculpture. The technical deficiencies of the works
of the two centuries just surveyed were not replaced by any
valuable development of style or use of material. Even when a
wider practice may have induced some greater readiness and
facility of mere execution. The monumental form, of recumbent
dead or dying and praying figures was still preserved. Either
by prescription, habit or feeling, this style of treating the subject
was happily and properly maintained; but, it will be seen that
a new and not an improved feature was admitted into these
designs, which interfered disadvantageously with the spirit of
the old types.

The tomb of the royal founder of the chapel, upon which are
placed the effigies in bronze gilt of Henry VII. and his Queen
Elizabeth, is so well known, that it would unnecessarily intrude
upon our space to describe it in detail. The statues as well
as the accessories, were designed by a celebrated sculptor
of Italy, Pietro Torreggiano, the contemporary and rival of
Michelangelo. These figures, in royal costume, are placed on a
tomb of black marble, at the corners of which, somewhat uneasily
balanced or sitting, are four nude cherubs or angels. The
monument is concealed within an elaborate and secret, or "closure," also of bronze gilt, but now, like the statues,
blackened by the rust of ages.

This might properly conclude our necessarily brief notice of
this marvellous chapel; but as the name of Torreggiano has
been mentioned, it will be right to direct attention to the other
works to be by him, in connection with this chapel. In
the south aisle is the effigy, in bronze gilt, of Margaret, countess
of Richmond, the mother of Henry VII. The aged and noble
lady is represented in the dress of a nun, with a mantle over all.
The details of this figure deserve careful examination. The
hands, in the act of prayer, are very true in character and form,
and give the idea of having been cast from moulds taken from
nature.

It need scarcely be said that the accessories of Torreggiano's
works exhibit much of the bastard Italian style of his school as
opposed to true Gothic; and there can be little doubt that the
furnishings of the immense pre-Reformation churches are
in accordance with certain Gothic traditions, to be traced to the employment
of foreign artists on the more important monuments erected in the
churches of this country. The recumbent effigy was still in-
cluded in them, but the accessories were not strictly required to
harmonise with any particular style of architecture; and thus,
especially in the case of the Pre-Raphaelite pendicular phase of
Gothic, are found the most capricious introductions of Corinthian and other architecture of the debased
forms of the classical orders,—precisely as they occur in con-
tinental design of the time. As this corrupt style was introduced
in this country about the time of the Reformation, it has been
said, without any reason, that the Reformation was the cause of
the change and fall of religious or ecclesiastical art; when the
fact is, the same bad and even worse taste is found in Italy,
from whence it reached England. The sixteenth century gives
a date to this false style of design; but the corruption of taste
is to be sought for, as numerous monuments show, in the production of those countries which, at that time, were much
more advanced in art than England.

The period of true Gothic sculpture may be considered to be
completed at this date, the middle of the sixteenth century. Already sculptured monuments of a more mixed style were
executed, and it will be seen that this, in a very short time, employed and utilised the old simple character of Medieval and
ecclesiastical art.

It has already been seen that lofty, highly enriched canopies
formed a striking feature in the early monuments of the Gothic
period. The same protecting roof or shrine is found in the
monumental design of the post-Medieval time, and equally
exhibiting a great quantity and variety of decoration. Colour,
gilding, inlaid marbles, armorial emblazonment, scrolls, were
profusely employed, as in the same class of design in the four-
teenth and fifteenth centuries; but though there is quite as much
meaning in the lozenges, twisted columns, urns, and other orna-
ments in these monuments as in crockets, finials, cusps, trefoils,
and the other fanciful devices of the Gothic canopies, the latter
were part of, and in harmony with, the architecture with which
they were associated; while in the recumbent figures of the
sixteenth and seventeenth centuries were not. This independ
ence of other circumstances, constitutes the great difference
between the two; and it must be admitted that, in an art point
of view, the latter offer no compensating qualities. Two
monuments in Westminster Abbey, of great historical interest,
are the tombs of Mary Queen of Scots, and of Elizabeth Queen
of England. The former stands in the centre of the south aisle
of Henry VII.'s Chapel; that of the English queen in the north
aisle. As in the monuments of the earlier style, the effigies of
the princesses form the main subject of the design. The
inferior character of the sculpture, generally, is at once evident.
Mary is represented in full dress, with her hands raised and
pressed together, as in prayer. The dress is elaborately
worked, but is wanting in true artistic treatment; the folds not
falling gracefully, but composed in heavy and straight lines, as
in a standing figure, and then gathered in uneasily confusion
at the feet. The hands have suffered injury, some of the fingers
being broken off; but they are small and elegant in form; and
the face, young, and having a gentle expression is of a pleasing
character. The architectural portions are cumbrous; and every
species of decoration that could be crowded into the design is
here introduced.

The monument of Queen Elizabeth is not on quite so large a
scale as that of Queen Mary, but it is composed on the same
principle, exhibiting profuse and cumbrous ornamentation totally
devour of taste. The effigy surmounts an elevated table tomb.
The Queen is in royal costume, with a small crown on her
head. In her left hand she holds a globe, in the right a sceptre.
The drapery is in large quantity, ill designed, and like that of
Queen Mary, stands up stiffly, instead of falling over to the
ground. The order, if it can be so called, of the architecture
of these two monuments is Corinthian; and therefore entirely out
of harmony with this beautiful chapel of a most enriched
character of Perpendicular.

Three very remarkable examples of this mixed character offer
themselves to notice in this (Henry VII.'s) chapel. They are
the monuments of Villiers, Duke of Buckingham, and his family;
of Sheffield, Duke of Buckingham; and of the Duke and Duchess
of Lenox, in three of the chapels at the east end of the nave. These fully illustrate all the peculiarities referred to, and they are, also, very good specimens of the state of art at the time. In the large composition of the Lenox monument there is much to move a much feeling in the spectator; the figures and even the men as mere accessories, are seen arranged in niches in the lower part of the tomb. In the later monuments these accompaniments assume a much more important and less ornamental character, as in this case, by the boys, winged and fluttering about, or sitting or standing in different parts of the monument, take the place of the small, draped, kneeling figures that support the pillow of the deceased in the Gothic monuments; while lines of sons and daughters, sometimes life-size, are placed in the base, or in the background of the design, kneeling, or praying against a lectern. The males usually are arranged on one side, the females on the other. Another peculiarity is often seen in these family tombs; and that is the introduction of deceased children, wrapped in swaddling or grave clothes, lying horizontally, on the side of the sex to which they belong. The monuments of this style,—like the old masters, in this, in which the artist is the closed and painted, and a variety of materials is used in their composition, as coloured marbles, alabaster, and brass, which, at least, produce a gorgeous effect, if they cannot be reconciled with good taste.

The Abbey possesses many examples of these designs, in which the figures, both in the foreground and in the background of the design, are mingled, the latter being intended to be suggestive of the life of the deceased, and to eminently mark his station in the society of the living. The figures in the Abbey are by no means confined to the altar, and the background of the design is often as much more than life-size, and are placed in the base, or in the background of the design, kneeling, or praying against a lectern. The males usually are arranged on one side, the females on the other. Another peculiarity is often seen in these family tombs; and that is the introduction of deceased children, wrapped in swaddling or grave clothes, lying horizontally, on the side of the sex to which they belong. The monuments of this style,—like the old masters, in this, in which the artist is the closed and painted, and a variety of materials is used in their composition, as coloured marbles, alabaster, and brass, which, at least, produce a gorgeous effect, if they cannot be reconciled with good taste.

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The Civil Engineer and Architect's Journal.

Medieval monuments, still, the later monuments continued to show the religious impulse, and invite serious reflection. In the eighteenth century this principle began to be lost sight of, and in the end utterly disregarded. Truthfulness and individuality were, as has been shown, first sacrificed to the absurd fancy of introducing the pseudo-classical. But the sculptor, for whose mental the artist proceeded to personal pseudo-classical decoration; and we find the deceased English nobleman, statesman, or soldier, dressed in a Roman cuirass, or toga, or paludamentum, mixed up with modern costume. The large monument of Sheffield Duke of Buckingham, before alluded to, in the chapel of Henry III. of St. Clere, is ornamented with a cuirass, sandals, and a full-bottomed wig, in the south aisle of the nave; and many others, will show the extent to which this absurd fancy was carried. It may not be amiss, to notice another class of monumental design, in which it is difficult to trace any motive. One example of this utterly meaningless application of art,—if, indeed, it can come into the category of art at all,—is the huge monument in the chapel of St. Paul, in memory of Lord and Lady Hunsdon. The date is about 1600.

This composition, measuring between 30 ft. and 40 ft. in height, and occupying one end of the chapel, consists of various stages of merely architectural details over and around a sarcophagus; while others are, without regard to any variety of objects, crowd the work from the pavement upwards; the most striking object being the large shield with the emblazoned coat of arms of the family. The whole has been profusely decorated and enriched with colour; now, in the course of time, sobered down into a most sombre blackness. Another striking feature of this kind of monument is the position of the north aisle of the nave. It consists entirely of various arms used in military life, and has more the appearance of an advertising card of an army accoutrement maker that a memorial record of a deceased soldier. These works are simply referred to as belonging to our general subject. It will neither be necessary nor profitable to continue the review of such trifling and unmeaning art.

Having now rapidly reviewed the monuments preserved in Westminster Abbey from the earliest reignal monument—that of Henry III., of the thirteenth century, down to the end of the eighteenth century—it is not necessary to make further remarks upon the monumental productions of a more recent time. It may merely be observed, generally, that while they often exhibit very advanced knowledge and technical power in sculpture, highly creditable to their authors, they are usually simply personal memorials, and have no serious ecclesiastical character or treatment to make them fitting objects to occupy places in a church. The more ambitious designs are made up of classically draped or even of nude statues, imitations of the antique. Others, expressing the views of the realistic or naturalistic school, appear dressed in the ordinary coats, waistcoats, and breeches of their day. Some are represented in the full vigour of life, making even such an impossible figure as to almost defy the imagination. Some are standing, in attitudes more or less graceful, doing nothing. Some are sitting comfortably in their arm-chairs, unoccupied, or, it may be, thinking. In none of these is there the slightest idea of fitness or propriety, with reference to place. Indeed, there are instances in which the extreme want of harmony with surrounding monuments and associations makes such productions not merely inappropriate, but positively offensive to good taste and feeling. They ought never to have been placed in the positions they occupy; and it is even now much to be desired that the more prominent of these statues, especially the single ones,—the most easily dealt with,—should be removed to other sites where, while the deserts of their originals may be honourably recognized, and the statues raised to their memory be seen by their admiring countrymen, they should no longer be permitted to crowd the floor of a place of worship; where the mind should be occupied with other thoughts than those likely to be suggested by such incongruous associations.

It is not intended, nor is it desirable, that works once admitted into the Abbey should be removed with anything like contumely and disrespect, simply because they do not harmonize with religious sentiment, or are out of keeping with the architecture of the church. It is not necessary to insist that such works, within the sanctuary, as it were. A cloister, for example, might easily be erected, fitted to receive them, or they might be aranged within the restored Chapter-house. Many of the detached statues, especially, might so be placed with great propriety, and with distinguished effect. Many of the larger compositions, which interfere fatally with the architecture of the church, cannot, it may be feared, be removed; but the evil arising from the church itself would thus be freed, in a great measure, from the crowding of works as inappropriate as they are obstractive.

The New Chemical Laboratories at Bonn and Berlin.

The thirteenth report of the Department of Science and Art has an appendix communicated by Professor Hoffman on the laboratories now being built at Bonn and Berlin under his superintendence. The professor's report is interesting for the special information which it contains, and remembering the intimate and increasing connection between chemical science and our manufactures, is very suggestive of what might be done in England for similar purposes. The following abstract of the report refers to the laboratory at Bonn.

Dr. Hoffman states that of the six Prussian universities, two—and these the most important ones—the Universities of Bonn and Berlin—have already provided laboratories for the teaching of chemistry in keeping with the advancement of science and corresponding to the demands of the present day; and after referring to the difficulties that stood in the way of the execution of this great undertaking, expresses his belief that the foundation of the two great chemical institutions now being carried out under the management of the Prussian Minister of Public Instruction, has at a significance far beyond the more immediate impetus they are sure to give to the prosecution of chemical studies in the universities to which they belong. By the grant of means unusually large for the organisation of these new schools, a tribute of recognition has been paid to the influence of chemistry on the modern aspect of the works of man that cannot remain without effect, upon other departments of physical science which have not been less productive of useful results.

Side by side with the two new chemical schools now springing into existence, other institutions are sure to be founded, similar in nature and appointed with a similar object. The prosecution of the two other great branches of natural science, physics and physiology, to which, as well as to chemistry, the future belongs.

This subject is already being freely agitated in the Prussian universities, especially those of Bonn and Berlin. The leaders in the several branches of natural sciences are persuaded, that the great efforts at the present moment being made for chemistry will, sooner or later, benefit their own departments. It is not, however, in Prussia, or in Germany alone, that the wholesome influence of this example appears to be felt. The exertions of the Prussian Ministry of Public Instruction in the cause of chemical science have attracted the attention even of foreign governments. Inquiries respecting the new institutions have already been made by several other countries, more especially by England and France, and it is not unlikely that the noble precedent set by Prussia will soon be followed by the establishment of similar schools elsewhere. It is in this sense, at all events, that the writer ventures to interpret the desire expressed by Her Majesty's Government to obtain information on the subject of the two institutions in process of organization in the Universities of Bonn and Berlin, which, at the request of the Prussian Minister, he has endeavoured to supply by drawing up the following statement. He would, indeed, consider it an honour to undertake the prosecution of this report, which, from the nature of the case, cannot be more than an outline, should assist in augmenting the interest already felt for the establishment of a great chemical institution in the metropolis of the world, an institution which England can no longer dispense with, since no country is more deeply interested than she is in the rapid diffusion of the latest results of chemical science.

The first negotiations respecting the building of a new laboratory in Bonn go back as far as 1861. In the summer of that year the reporter was invited by his friends, Professor Plücker and
and Sell, to an interview with Mr. Beseler, the Curator of the University of Bonn. But little time elapsed before the first steps for the foundation of the new chemical school were taken. The institution was opened in the winter of 1858, and liberally provided with all the requirements for modern investigation. The question thus opened led to a series of negotiations which ended, in the spring of 1863, in the reporter complying with this proposal.

The important duty of drawing out the plans of the new institution devolved on Mr. Augustus Dieckhoff, architect to the University, and in preparing the programme, the composition of which fell to the lot of the reporter, it appeared all-important to gather information as exact as possible respecting the chemical institutions already in existence, and the reporter was fortunate enough to obtain drawings and plans of nearly every existing laboratory. The chief experience, however, was gathered during a journey of several months through Germany, in the autumn of 1863. On this trip nearly all the German laboratories were studied, from that of Giessen, the first German university laboratory, which the father of the reporter built more than a quarter of a century ago for Liebig, down to the more recently-founded chemical schools in Karlsruhe, Munich, Zurich, Heidelberg, and Göttingen, and the splendid institution just completed in the University of Greifswald.

Ultimately a plan, the detailed contract for which amounted to 183,000 thalers (£18,450), passed, with scarcely an alteration, the several stages of supervision, and was sanctioned by Government.

The first turf was turned late in the autumn of 1864; the spring of 1865 saw the foundation stone laid; and the building, the construction of which was entrusted to an able young architect, Mr. Jacob Neumann, who had already efficiently assisted in laying out the plans, is at present being roofed in, so that in the course of the summer it can be handed over to the university.

The new chemical institution is provisionally intended for 60 students; the space, however, has been met out so liberally, that accommodation could be supplied without inconvenience to a much greater number; besides this, the building has been so constructed as to allow of enlargement at any future time, by raising a second story, without detracting from the harmony of its structure.

In addition to the various apartments required for educational purposes, for practical analysis, for scientific and technical investigations, and, lastly, for the lectures, there are in the new building sets of rooms for the castellans of the institution, for the count and countesses, and for the assistants, and also a magnificent residence for the director, consisting of a suite of rooms which as regards number and extent, could be very seldom met with in a private house. Lastly, there is a considerable number of well-lighted basement rooms, which have as yet no special use assigned to them, but the construction of which could not be avoided.

The various departments of the building are spread over three floors, the basement, the ground floor, and the first floor. The first floor, however, extends over but a small portion of the structure, and is exclusively occupied by the private apartments of the director. But few of the rooms devoted to the purposes of the institution are found in the basement, as, for instance, the laboratories, the rooms for metallurgical and other operations requiring large quantities of fuel, those for medicoo-legal and chemico-physiological research, &c. All the remaining space intended for educational purposes, viz., the laboratories, with their adjoining rooms for special operations, and side-rooms, balance-rooms, etc., are found on the ground floor. In addition to the auditorium, the hall for collections, the study and private laboratory of the director, the apartments of the assistants and other officers of the institution, are, one and all, on the ground floor, an advantage which would not have been obtained had the site of the building been of more limited dimensions.

As the building has more than 44 rooms, exclusive of vestibules, corridors, and closets, its dimensions necessarily became very considerable. Four outer wings enclose an area of very considerable size, divided into four quadrangles or courts by a cruciform interior building. Those parts of the edifice surrounding and two back courts are exclusively devoted to the purposes of practical instruction in chemical analysis and research, and the small windows in the walls which separate the two front courts from each other includes the lecture theatre, with the rooms pertaining thereto; in the south-west side wing of the left front court is the private laboratory of the director, with the rest of the rooms devoted to his use. The corresponding north-east side wing of the right front court is occupied by the apartments and offices of the assistants and other officers. The ground floor of the front part of the building, lastly, is devoted to the scientific collections of the institution and a small theatre for special lectures.

The main entrance for students, as well for those working in the laboratory as for those who only attend the lectures, lies in the principal side-front facing the city of Bonn.

After ascending the stairs we enter a large vestibule richly decorated. Before the spectator stretches a long corridor of considerable width, the main artery of the entire building, brilliantly lighted by a number of windows on the left side. The large folding doors at the further end of the corridor, visible from and directly opposite to the main entrance, lead to the director's spacious study, which is provided with a large bow-window for microscopic observations; from this central situation the various parts of the great building are quickly and easily accessible. On the right-side the great corridor branches out into three side-corrugus leading to the entrances of the three principal buildings, and terminates in two smaller halls, by their position arranged on the two sides, and providing 20 students with more than sufficient space and every convenience for work.

Permanent working-places for 60 students, which, as already mentioned, the institution is to accommodate, were thus secured. According to this disposal of the space, the students range themselves in three classes—Beginners, that is to say, those who having become acquainted with the rudiments of chemistry by attending lectures, enter the laboratory to become exercised in chemical manipulation, to make preparations, and to go through an elementary course of qualitative analysis. 2. Advanced students, or those who, having acquired practice in qualitative experiments, are occupied with quantitative analysis, both ponderal and volumetric. 3. Young chemists, sufficiently versant with the principal department of chemistry to engage in the original experimental investigations, either suggested by the director or chosen by themselves.

A division of this nature, whereby the three classes are distributed in separate rooms, seemed expedient for more than one reason. Not only was it possible to fit up each laboratory in a manner suitable to the wants of each particular class, but the situation of the rooms themselves could be so adapted to the remaining parts of the building as to offer the greatest facilities to the students, from a practical point of view. The learner still must be rated the advantages as regards readier supervision and increased means of maintaining discipline in all parts of the institution afforded by an arrangement of this kind.

The good arising from a large number of students working together in an extensive institution is unmistakable. If the student have but his eyes open to the work of his neighbours he has opportunities of gaining, in a comparatively short time, an amount of experience which, working alone or in company with only a few, he could scarcely gather during years of diligent labour. It is the chemical atmosphere in which he works that promotes his progress.

The institute is, indeed, cease when the number of learners exceeds those limits within which personal supervision is still possible. As soon as the beginner is no longer conscious that he is able to procure help at any moment—as soon as the more advanced student no longer feels that he receives individual attention—lastly, as soon as the young chemist, though with an eye on the authorities satisfied that an experienced eye watches over his steps—the chemical institution, however excellently it may be organised in other respects, will yield very small results indeed. It is, therefore, of the first importance for the director of such an institution to have the necessary teaching power by his side. According to this idea the episcopal vicar appointed a assistant to superintend, for any length of time and with satisfactory results, the labours of more than twenty students. Acting upon this experience, the Minister of Public Instruction decided to appoint
for the Institution of Bonn three scientific assistants, who, under the guidance of the director, are to watch over the experimental studies of the students. The disposal of the students in three separate laboratories seemed to accord particularly well with this provision.

In the individual laboratories the students have their permanent working places. To each one is allotted, for this purpose, a table amply supplied with gas and water, as well as lock-up drawers and cupboards in which to keep apparatus, re-agents, &c. At these working benches all ordinary chemical work and all operations, not requiring the special arrangements provided in other parts of the laboratory, can be conducted by means of gas, and carried on in special "evaporation niches" let into the walls, and communicating directly with the outer air by means of wide tubes of glazed earthenware.

Turning now our attention to the side apartments attached to the three laboratories, we have, in the first place, to mention three closets in direct communication with the main rooms. They are in charge of the respective assistants, and are intended for preserving delicate and costly apparatus, platinum and silver vessels, expensive re-agents—everything, in fact, of which special care has to be taken.

There are certain operations which cannot be well conducted in the three laboratories referred to. On this account they are connected with a series of rooms devoted to special purposes. There are three rooms, directly communicating with the laboratory, in which the students can carry on work, such as distillations, making of gases, heating of bodies in particular gas-atmospheres—in short, all experiments requiring large and complicated apparatus, are conducted at the benches fitted up in these rooms or in the "evaporation niches" let into the walls. In case, however, on any particular occasion, even more space should be required, each operation room communicates with a covered colonnade, opening towards a back court, and fitted up with gas and water and all the requisites for work. From these colonnades the basement of the building, containing a variety of rooms devoted to the objects of the institution, and more especially the metallurgical laboratories, is accessible by means of spiral passages communicating with the rooms of the basement, and leading up the long and winding flights of the outer walls. Flights of stairs on the other hand, lead from the upper sides of the colonnades down to two back courts lying between the three laboratories, and here the student finds an additional supply of water in large central reservoirs, the tabular parapets of which serve as working benches for a variety of operations.

The three operation rooms, situated behind their respective laboratories, are not of equal dimensions. In apportioning their size especial attention had to be paid to the wants of the beginner and of the independent worker. The beginner who practises the various forms of chemical manipulation, preparing gases, making distillations, condensing acids, has to be provided with ample space in which to develop his activity. In like manner the young chemist engaged in actual research may at any moment want to fit up new or reconstruct old apparatus, often of a complicated nature, for the particular objects of his investigation; tools of the most various description, hammers, files, vices, &c., are thus constantly required and are kept in certain blue cupboards close at hand, or even at rest. For him too it is of vital importance that he should not be cramped in space. For this reason the operation rooms connected with the two wing laboratories, and expressly intended for the classes just mentioned, are made as large as possible. The students of the second laboratory, principally occupied with qualitative analysis, have therefore had a less spacious operation room allotted to them. By this arrangement an additional small apartment was gained, symmetrical with this operation room, and serving as an approach to a very important part of the institution, viz., the laboratory for gas analysis. This spacious apartment comprehends the middle part of the building at the back, and is thus almost equally accessible from the three laboratories; it is on the other hand sufficiently removed, more especially by the intervening ante-room, from those parts of the building where the chemical business of the institution is most active, to allow of the delicate measurements here made being carried out without disturbances. The test tubes most delicately situated have been placed in spaces cut off by three smaller windows situated in a central projection; but all the light coming from the south can be shut out by means of strong well-closing shutters, thus securing to this apartment the uniform temperature so important in gas analysis.

Along the main corridor lies a series of rooms opening upon it, and serving as an approach to the various departments of the institution. Close to the vestibule, immediately to the right and lying between the entrance to the first and second laboratories, is, first of all, the volumetric analysis room, where are kept the standard solutions, daily increasing in variety, as well as the graduated vessels.

The balance room, the next in order, is not only intended for the reception of chemical balances, but also of the more delicate physical instruments made use of in analysis, such as air-pumps, barometers, &c.

Next follows a room for fusions and ignitions, capable of being carried out by means of gas. Here are the necessary appliances for the various heating operations occurring in mineral analysis. This room is also fitted up with all the requirements for organic analysis, distillation apparatus, and special storage closets, likewise entirely conducted by means of gas, and carried on in special "evaporation niches" let into the walls, and communicating directly with the outer air by means of wide tubes of glazed earthenware.

This room also contains the ranges of water ovens required for drying the substances to be submitted to analysis. In these ovens, which are heated by the steam of the stills for distilled water in the basement, every student has his own compartment under lock and key. With respect to the uses of these three rooms, they are more especially intended for the workers in the middle laboratory; they are, however, accessible to the beginners.

The balance-room is purposely situated in the middle, and separate from the neighboring rooms on the one side, and the room for fusions and ignitions on the other, so as to protect as effectually as possible the costly instruments of this room from the fumes which, in spite of all ventilation, at times escape in a laboratory. The situation of the balance-room, between the two others, affords an additional and by no means trifling advantage; numerous operations proceeding the weighings, such as drying substances in the water bath, heating crucibles, collecting the combustion products in organic analysis, &c., all take place in the immediate neighbourhood of the balance, whilst on the other hand the preliminary weighings, invariably forming the first step in volumetric analysis, can be made in close proximity to the rooms of the early stages of volumetric observation. The three rooms therefore communicate directly with each other.

Between the second and third laboratories are, in addition to a small flight of steps leading to a number of attics over the ground floor, three precisely similar rooms, accessible from the corridor, and with doors opening into each other. Of these, the one nearest the second laboratory is intended for the library.

The main results of chemical investigation are duly registered in treatises and manuals, and are therefore easily within the reach of students. But the statements to be found in books of this description cannot be more than abstracts, always very condensed, and often more or less garbled, from the memoirs of the first observers. As soon, therefore, as the student has got beyond the first rudiments he can no longer dispense with original sources of information. The main bulk of chemical observation is collected in a series of periodicals and journals, the volumes of which are counted by hundreds, and if a student wishes to consult the works which have to be consulted in the prosecution of even limited investigations in most cases far exceeds the power of any single individual. These books could of course be readily procured from any public library, but reference to original communications is too often omitted if the work is carried on by specially selecting it. On this account every chemical school possesses a library, more or less complete, offering to the student a copious collection of original memoirs, which he can consult at the very moment he may require their assistance. The use, it may be said the necessity, of such libraries is so apparent that students themselves have in a great measure begun to be regarded as the right holders of representation and subsequent development. In this way, from but small beginnings, some most complete collections of chemical works have been formed. The reporter, when a young student, had the good fortune to take part in the establishment of such a laboratory collection, under the auspices of his illustrious master, Baron Liebig, appreciate; this is now the oldest, and probably the largest chemical library extant. In later times he had the pleasure of assisting in the inauguration of a similar collec-
tion for the Royal College of Chemistry, London. Such a library is of course in contemplation to establish for the Bonn laboratory, and already, long before its opening, a number of books have come in as presents. The situation of the room set apart for this purpose in the second and third laboratories, is peculiarly appropriate, because it is more especially to the students of these two laboratories that the library will be of use, whilst its slight distance from that part of the institution where the director carries on his own researches is likewise a great convenience to him and his assistants. The two rooms lying between the second and third laboratories are a balance room and a room for fusions and ignitions. With these rooms, on the right-hand side of the principal corridor, terminate the ground-floor apartments intended for practical instruction. We have now only to glance at the theatre and adjoining rooms for preparing lectures and preserving apparatus, models, drawings, and collections of all kinds.

The students attending chemical lectures in the German universities are always much more numerous than those who work in the laboratories, and, therefore, more accommodation had to be provided in the lecture hall. A lecture room capable of holding 500 students appeared to meet the requirements of the University of Bonn. An area of 40 feet square was found sufficient for this purpose, and at the same time to afford ample space for the lecture table, as well as for the free movement of the lecturer and his assistants.

In the great lecture hall, the seats are arranged like the tiers of an amphitheatre, and in the lower part, just opposite the entrance, is placed the lecture table, 40 feet long and 3 feet 4 inches wide. In the lower part of the wall, behind the table, are the evaporation and ventilation niches for experiments, whilst on its upper part drawings and diagrams can be exhibited. The lecture room is lighted from both sides, so that neither professor nor audience is obliged to face light which has to be appreciated by any one who has been either lecturer or hearer in a room of different construction. The fourteen windows which supply light on either side are arranged at a height of nine feet above the floor of the hall, except the two next the lecturer, which descend to the level of the table, enabling him to exhibit many colour-phenomena by means of transmitted light, and to employ sun-light, under favourable conditions, as an agent in his experimental illustrations.

The theatre communicates with the laboratory of the lecture assistant by means of two side doors, and a large niche in the centre of the wall. Here everything required for the lecturer is got, and for the lecture assistant for this purpose all necessary furniture and benches are provided. In this room larger pieces of apparatus can be fitted up upon a table moving on rails, which can be run through the niche already mentioned in the theatre during the course of the lecture. This laboratory is lighted from both sides, on the north-east by a large window, and on the south-west by two smaller ones, and, as all the windows face south, there is no light to be wasted by one window, which is used for the preservation of the various documents belonging to the lectures, such as printed forms, lists of students attending, &c., and where the professor may stay before entering the theatre, and receive those students after the lecture who wish to consult him. This room, called the "waiting room" to this lecture assistant, is the mineralogical museum, one of the great halls assigned to the scientific collections of the institution. This hall, as well as the one next to it, which being profusely lighted by six windows symmetrically disposed on both sides, is intended for the chemical museum, is in the front block of the building. Close to the mineralogical museum is a small lecture room for recapitulations and special lectures to be conducted by the assistants.

All the rooms for apparatus, chemical preparations, &c., used in the lectures are situated between the two rooms devoted to oral demonstrations, so that all requisites for the lectures can be conveyed with the greatest ease either to the larger or the smaller theatre, and back to the collections. It was not without intention that the somewhat removed from the busier departments of the institution. The experience of the reporter, which is not unlikely to receive confirmation from others, has taught him that the love of research and zeal for discovery in young chemists, however praiseworthy in itself, is at times anything but conducive to the increase of scientific collections.

The large halls for the mineralogical and chemical collections, together with the smaller theatre and its preparation room, occupy almost the entire ground floor of the front block of the building. In addition to these are still to be mentioned two vestibules, leading the one to the main staircase, the other to the back staircase ascending to the apartments on the first floor; then immediately to the left of the north-east entrance a lodge for the porter, and, lastly, close to the south-west entrance, apartments for one of the junior assistants of the Institute.

Of the two sideways, the one stretching out at right angles from the left of the main vestibule in the north-east front contains the porter's lodge and other apartments while the other side wing is entirely devoted to the scientific purposes of the director, with whose study this part of the building is in immediate communication. Of the rooms situated in this wing mention must first be made of the private laboratory of the director, which is lighted by four windows. Opposite to this lies the director's waiting room, accessible from the main corridor, and communicating with his study by a short private passage. Beyond the other end of the private laboratory are two small apartments, one to be used as a balance-room, the other as a room for ignition, fusions, and combustions. The latter has a small vent to a cortice for experiments required to be performed in the open air.

The basement is, to all intents and purposes, a repetition of the ground-floor, the greater thickness of the walls, however, lessening the amount of space to some extent. The rooms in this part of the building are 19 feet in height from the floor to the top of the arches, and are sufficiently lighted throughout, by numerous windows of comparatively large dimensions.

Along the main corridor of the basement are two spacious rooms, of which the first is intended for the storage of solid, the other for that of liquid reagents. Both store rooms are close to the flight of stairs leading on one side into the courts, on the other to the door leading to the ground-floor, whereby the chemical to and from the store rooms, and thence to the main body of the institution is greatly facilitated. The same accessibility to the floor above pertains to the other two rooms along this corridor, and has determined their special use. In the one nearest to the staircase a steam boiler will be set up, while directly commencing with the steam boiler room, a time accessible from the corridor, is a large and well lighted apartment intended for rougher kinds of work, and especially for a general wash-room, where apparatus of all kinds can be readily cleaned. For all these purposes the closeness proximity of the steam boiler is an especial advantage. In this room, moreover, a large press will be fitted up, in the use of which for hot pressing purposes the steam, close at hand, may likewise be turned to account.

At the extreme end of the corridor is a fine well-lighted room, corresponding in form and size with the director's study on the floor above; this is a store-room for the large stock of glass and porcelain belonging to the last rooms. The last room, a communicating passage, contains two furnace rooms for smelting operations, carried on by means of coal and coke. The larger of these, that situated in the middle, is for students of the second and third laboratories; while the smaller one is for the beginners.

These laboratories are purposely located in the basement, the greater height of the chimney ensures a considerable increase of draught. They are, moreover, far less frequently used than the rooms on the ground floor. Lastly, the dust and dirt invariably attending the use of coal is thus almost entirely
excluded from the flat above. The furnaces and appliances set up in these laboratories are of a varied nature; among them specially protected niches for operations carried on under great pressure, such as digestion of substances in sealed tubes, &c., deserve particular attention.

For the storage of the fuel required for the furnace-rooms, four coal cellars have been provided.

With regard to the courts themselves, it deserves to be mentioned that the two front courts communicate by means of a thoroughfare cutting the front wing of the cross building immediately under the landing of the theatre staircase; in this manner any one of the four courts can be reached through the carriage-way facing the town, without entering the interior of the building. Such a disposition is of great use for the preservation of cleanliness throughout, and of absolute necessity in order to render all parts of the building accessible in case of fire.

Attention must still be directed to some of the rooms situated on the basement of the front part of the middle wing.

On descending from the ground floor to the basement, we pass through the vestibule into a large workshop lighted by three windows. Here the rougher work required for the lectures is performed; here liquid carbonic acid would be prepared, and here, in a well-ventilated niche, stands the large galvanic battery already mentioned, the wires of which, passing through the floor of the theatre above, communicate with the electric lamp, now rapidly becoming an indispensable appliance of the lecture-table. Further on is a small laboratory for medico-legal investigations; it is lighted from both sides, and being accessible only to the director and the lecture-assistant, is effectively protected from all undesirable intrusion. Beside the room for the rougher lecture work there is a small cellar communicating with the vestibule, in which compounds requiring a low temperature, explosive bodies, such as gases condensed in hermetically-sealed tubes, like sulphuric acid, chlorine, &c., are preserved. Substances readily undergoing decomposition, generating corrosive vapours, or in any way dangerous, can thus be conveniently excluded from the general collection.

The external aspect of the new laboratories is in perfect keeping with the scale of grandeur of the ground plan. The street front is 180 feet in length; the side front, with the main entrance for students, has a depth of 250 feet.

Only the rear block of the building has a second story; this contains a most splendid suite of apartments provided for the director of the institution. This residence is richly ornamented, and will in all respects be worthy of the institution to which it belongs. The reporter must not enter into any details upon this subject, but he cannot leave unnoticed the imposing entrance hall, illuminated by a glass cupola above, and the splendid ballroom, extending through two stories, amply satisfying the social requirements of a chemical professor of the second half of the nineteenth century.

SELF-ACTING HYDRAULIC COAL-CUTTING MACHINE.*

BY W. E. CARRETT, ENGINEER.

In the general detail of mining operations, the cutting away of the under portion of a valuable seam or bed of mineral to facilitate its subsequent removal, is at all times one of the most laborious and difficult operations, and is often effected by the miner under the greatest physical disadvantages; more especially when the seam of coal is very thin, and is cut on the “end” to improve its saleable qualities. This “holeing,” or “baring,” or “tirving,” or “undercutting,” is usually performed by about 40 blows per minute from a pick, handled with such experience, as to raise 3 to 4 feet under, at the rate of 1 to 1.5 yards linear per hour, and destroying much of the coal to make room for the operator, and enable him to work partly into the hole, to produce the requisite depth for a fall.

The speed and effort with which this picking tool is moved, combined with its weight, represent the power of one man applied in the shape of “percussive force,” and this, under advantageous circumstances, is equal to about one-sixth of a horse power. The miner could not, with his limited power, force his pick, or any other shaped tool into the coal as if he were cutting cheese; he is like the mechanic, who has to chip all his iron work with hammer and chisel for want of a planing or sloting machine, and must reduce it by little as best he can, “in lieu” of suitable mechanical expedients to concentrate and apply power in a continuous, undeviating, and determined line. Yet the introduction of planing or sloting machines has not injured the mechanic, nor the morticing machine the joiner; there is ample work which the machine cannot do; and there are innumerable mines where no machinery can compete with the skilled miner.

To apply the power of horses in lieu of man-motive power, even though one horse is as powerful as six men, is practically very difficult. The power of both is dependent on the produce of cultivated lands; and the fewer horses required the cheaper the necessary for human sustenance.

There is yet a far more effective substitute for the power of both man and horse, which has been inviting our use for centuries, in the form of what George Stephenson conceived to be “bottled up sunshine.” A coal-fed steam engine, of one horse power, is twelve times cheaper than one animal horse power, and our obedient servant for 24 hours daily, consuming the produce of uncultivated lands on which the sun shone ages ago.

Now it is desirable that in many favourable circumstances this “undercutting” operation of the miner should be accomplished indirectly by this steam power, and one of the practical methods of accomplishing this object is the subject of present consideration.

If one collier had the power of say 18 men, and when necessary

* Paper read before the Nottingham Meeting of the British Association, Aug., 1860.
could make himself 2 feet high, and hold himself down upon the
floor of the mine by pressing his head against the roof, and hold
firm in his hands a kind of cheese scoop in lieu of a pick, and
could force it steadily into the coal at the necessary height from
the floor, and to the required depth, he would then be exactly
what is in many cases wanted: he would be a travelling mortising
machine, and do more in one minute than 700 blows from a hand
wrought pick can do, and would, in fairness, demand a very stiff
wage, which he would undoubtedly obtain.
This is what the Iron Man or Hydraulic Coal Cutter accom-
plishes. "He" is, if necessary, two feet high, has four legs, of
adjustable length; his head is also adjustable to touch the roof,
and he weighs one ton. He is fed by a 2 inch flexible pipe with
sober drink, at 300 lbs. pressure, and at the rate of 30 gallons
per minute.
This water pressure acts vertically on a 5 inch piston pressing
against the roof, and horizontally on one about the same size,
reciprocating 18 inches and 15 to 20 times in a minute. There
is a pressure of 5000 lbs. against roof, and the same pressure
acting horizontally, forcing three "cheese scoops" into the coal.
These cutting tools are 3 inches wide, and penetrate 4 feet, with
a power equal to 3 horses or 18 men; and this is effected by a
consumption of 50 lbs. of coal per hour to feed the boiler of the
engine, which makes the water pressure, and pumps the same
over and over again. Thus this Automaton Iron Man is dead
fast when forcing the cutters into the coal, and only requires to
lower his head 1 inch at the return or back stroke, and advance,
which he does also self-acting, at its termination, half-an-inch to
one inch, and then again he elevates his head and is ready for
the next cutting stroke; his sober veins being filled by incom-
pressible if not exhilarating "water," and retained therein by a
keep valve, for the necessary time, enabling him at that moment

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**Fig. 2.—Ground Plan. Scale, 1 inch to 1 Foot.**
to defy the roof to crush him. This Self-acting, Hydraulic, Coal-cutting Machine, or "Iron Man," which has now been two years at work, is the miners' best friend; it does not dispense with his labour, but performs for him the undercutting, which is a most laborious operation, either in the end or face of coal, and in a more efficient and economic manner than he can do it himself. The coal so operated on by the Machine does not fall forward when becoming detached from the roof, but settles on the lower bed, thereby avoiding serious accidents. The wearing in coal alone more than pays for the outlay; and it is practicable to cut with the most perfect ease into the floor of mine, thus preventing all waste of coal whatever.—(See Fig. 3). The size of the coal is improved, the amount of slack is considerably reduced, and a single seam will yield more by one thousand tons of coal per acre, than when worked by hand labour in the usual manner.

The Machine undercuts "holes," or "kirves," with a man and boy as attendants, and completes the work with once going over, at the rate of fifteen yards per hour, and at any angle and height from floor or rails, being suitable for either "dip" or "rise" workings, and is capable of cutting the thinnest seams. The pressure of water which actuates this apparatus can be obtained either from the stand pipes in the pit, or from pumps attached to any existing engine, or from an engine and pumps specially made for the purpose. The quantity necessary is only what is sufficient to fill the circuit of the pipes, using it over again when desirable, as in the Bramah press. Any idea of a large volume of water being necessary may therefore at once be dispelled. There is also no leakage whatever.

Each Machine uses thirty gallons per minute, at about 300 lbs. pressure, according to the hardness of the coal or mineral to be operated upon. In cutting the shale of the Cleveland ironstone band, a somewhat greater pressure is found to be necessary.

There is no limit to the pressure of water that may be used, nor the distance it may be forced without loss of power, beyond that due to its friction along the pipes. The same water pressure is also applicable to work pumps and rotative engines for hauling, &c., and other requirements in the mine, at a distance from the engine power. In cases where there is a fall of water, say of 100 lbs. pressure, it can be "intensified" by a self-acting Machine to 400 lbs. pressure, to work the coal cutter, but sacrificing three-fourths of its bulk, which is thereby set free.

The water is supplied in a continuous stream; it is, in fact, the medium through which the mechanical power is applied direct from the first coal-fed motor, (a Steam Engine and pumps) in lieu of the usually-developed power derived from vital energy, and applied to the handle of a pick, effecting the desired object by a series of percussive blows or impacts. The power of six men is equal to one horse, and is six times more costly; and the power of one horse steam motor, or engine, is eighty times cheaper than six men. The machine is about three horse power, and weighs one ton, and will work either right or left. (See dotted lines on ground plan). It is self-acting in all movements, and will ascend the steepest gradients; being simple in all its parts, it is not liable to get out of order, and is easily managed by an ordinary miner, and transported from place to place, on the ordinary rails, about the mine.

Although the length of stroke of each cutting tool is eighteen inches, the practical cutting length is sixteen inches, and, consequently, the three cutters jointly give a total effective depth of four feet at each stroke of the machine, finishing the work as it goes along. The mechanism employed consists of an Hydraulic reciprocating Engine, adjustable to any height and angle, having a self-acting valve motion. The cylinder is four and a-half inches diameter, and lined with brass, and the piston made tight with ordinary hydraulic leathers, easily renewable.

Within the piston rod is attached the cutter bar of steel, carrying the tools or cutters. These can be varied in number to suit the depth to be holed at one operation. The cutting tools are of double sheer steel, easily made, and very strong, and can be removed and replaced in a few moments; they are readily sharpened on an ordinary grindstone. The cutter bar is also removable, when transporting the machine from place to place, for which purpose the main cylinder is, for the time being, placed longitudinal with the rails. (See dotted lines in Fig. 1).

The machine in operation fixes itself dead fast upon the rails during the cutting stroke, and releases itself at the back or return stroke, and traverses forwards the requisite amount for the next cut, without any manual labour. Should the tools be prevented making the full stroke at one cut, they will continue to make more strokes at the same place, until the maximum depth is attained, when, "only" the Machine will traverse itself forward the required amount for the next cut. Thus, at one operation, a uniform straight depth is attained, parallel with the rails, inducing an even fracture when the coals are brought down, and thereby a straight line for the new coal face. There is no percussive action, either against the roof or into the coal, but simply a concentrated pressure, producing a steady reciprocating motion, at fifteen strokes per minute. There is consequently, no dust or noise, and little wear and tear. For the same reason, when cutting pyrites, the tools throw out no sparks, and the workman can hear any movement in the coal or roof.

The required height from the line of rails in the "hoeling," "kirving," or "baring," varies in different mines; it follows that the hydraulic cutting cylinder, and its direct action cutting tools, have sometimes to be arranged above the carriage, and sometimes beneath the main carriage, or close down upon the sails, as is illustrated in Figures 1 and 2. Figure 1 is the main carriage, with four wheels far enough apart to allow the machine
to be placed longitudinally when being transported from place to place. The screws \( \frac{3}{4} \) are for raising and lowering the carriage and its cylinder and cutting tools. The pinion \( z \) and the segmental rack \( H \) regulate the desired angle of the tools cutting into the coal face, and the two nuts at each end of carriage, \( xz \), regulate the required angle, when necessary that it shall not be too close to the main or side rails.

\( \text{AAA} \) are the cutting tools, \( n \) the cutter bar, \( n \) a guide roller for the same; \( d \) is the main cylinder, with its self-acting hydraulic valve motion, which passes a portion of its water alternatively above and below the piston of the holder on, which thus rises and falls without percussion, and follows the uneven level of the coal mine, so that the required stability is given to the machine for the time being, an instant before the cutters enter the coal. The "holder on piece" can be any length necessary to bridge over gaps in the roof; it is loose on the pin \( v \) and drops to its leading end to enable it to ride over the varying projections in roof. The traverse motion is actuated by the pin \( j \), which connects cutter bar with piston rod, and at the termination of each end of its stroke actuates the lever \( \delta \) in both directions, which operates on the pull \( e \) which causes the chain-pulley to revolve on the chain \( i \), made fast ahead by an anchor-rop between floor and roof.

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**ON THE HEIGHT OF ROOMS.**

To the Editor of the "Civil Engineer and Architect's Journal."

Sir,—I forward the enclosed paper to you, thinking that it is likely to be of interest to architects.

My object has been to show that perfection, or something approaching thereto, is possible, in fixing the proportions of rooms, by which word is to be understood not only all kinds of height, lengths, but also halls, theatres, etc. I premise that the theoretical perfection of the cube, the idea developed in the first part of my paper, is so noble; but, since it forms the corner stone of my theory, I have deemed it advisable, before going further, to demonstrate that it is a sound stone and one on which we may safely build.

As to the practical results to be looked for, I venture to hope that the suggestion I make will be found to exert an influence on the design of public buildings and country houses; but, so long as the staircase forms a necessary feature in a house, the limit of available space must unavoidably dwarf the rooms in town structures. 1

1. Dorset Place, N.W. H. N. CERILLIN, Jcn.

In order to solve the problem of finding the ratio which should obtain between the plan and elevation of a room, we have first to ascertain whether there be any such thing as a body of perfect proportions.

Now perfection, we must bear in mind, is completeness; a state in which there is neither defect nor redundancy; a symmetry such that nothing can be either taken away or added without deterioration, if not destruction. Making use of this definition as a test, we discover two forms, each perfect; the cube, among those bounded by straight lines; and the sphere, among those bounded by curved lines. For our present purpose we have to do only with the first.

The cube is a form the proportions of which are perfect, inasmuch as it admits of no alteration; there is perfect harmony among all its parts—each side is equal to every other, each line to every other,—so that no one part can be either diminished or increased without causing absolute destruction of the cube. We adopt this form then as our standard.

If therefore the four sides together with the top and bottom of a room be made equal each to each, the proportions thereof will of course be perfect. But that all our rooms should consist of a number cubic spaces would be not only monotonous but practically impossible. We have then to discover some formula by which we may determine the perfect height, or the height which in proportion to other measurements, most nearly approaches perfection, of any parallelepiped whether cubic or not. And we can discover this only by observing the ratio which the height of a cube always bears to the area of the base or side on which it stands. Now we know that this is invariably: As the square root of the area of the side is to the area of the side; consequently, given a superficial square, we see at once that the line of height to be adopted, in order to erect upon it a cube, must be the square root of its area. We apply this to any parallelogram.

Let \( R \) be a room, the length of which is to be \( L \) and the breadth of which is to be \( B \). \( L \) and \( B \) is then the area of its floor, and \( \sqrt{L^2+B^2} \) should be its height. For thus, not only does the height, \( \sqrt{L^2+B^2} \), bear the correct plane to the floor \( L \) and \( B \), whether those letters represent equal or unequal quantities, i.e., whether the room be cubic or not, but also, the volume \( L \sqrt{L^2+B^2} \) of the room is exactly that, which would be the case if \( L \) and \( B \) were the sides of a square.

I append the following as illustrations:

- Lords of G. 45 feet broad, 45 feet high. House according to formula: \( 90 \times 45 \times 4050 \). \( \sqrt{4050} \approx 63.63 \) ft.
- Case of Lords of G. 45 feet long, 45 feet high. Height according to formula: \( 75 \times 45 \times 3375 \). \( \sqrt{3375} \approx 58.37 \) ft.
- Guildhall: 152 feet long, 50 feet broad, and 55 feet high. Height according to formula: \( 152 \times 50 \times 7600 \). \( \sqrt{7600} \approx 87.17 \) ft.

**Egyptian Bricks.**—Professor Unger, in a paper recently communicated to the Imperial Academy of Sciences at Vienna, shows that Egyptian bricks possess a special interest, for they contain a variety of evidence preserved, as it seems, in an imperishable form. In his latest researches he has examined a brick from the pyramid of Dashour, which dates from between 3400 and 3300 B.C., and found imbedded among the Nile mud or slime, chopped straw, and sand of which it is composed, remains of vegetable and animal forms, and of the manufacturing arts, entirely unchanged. So perfectly, indeed, have they been preserved in the compact substance of the brick that he experienced but little or no difficulty in identifying them. By this discovery Prof. Unger makes us acquainted with wild and cultivated plants which were growing in the pyramid building days; with fresh water shells, fishes, remains of insects, and so forth, and a swarm of organic bodies, which, for the most part, are represented without alteration in Egypt at the present time. Besides two sorts of grain—wheat and barley—he found the teal, the field pea, the common flax, the latter having, in all probability, been cultivated as an article of food, as well as for spinning. The weeds are of the familiar kinds: wild radish, corn chrysanthemum, wart-wort, nettle-leaved goosefoot, bearded hare's ear, and the common vetch. The relics of manufacturing art consist of fragments of burnished pottery, of vessels, and a small portion of flax, and sheep's wool, significant of the advance which civilization had made more than five thousand years ago. The presence of the chopped straw confirms the account of brickmaking as given in Exodus and by Herodotus; and the whole subject is so interesting that it is to be hoped that Prof. Unger intends to follow it up. He is of opinion that, by careful examination of a large number of bricks, some light may be thrown on the origin of Egyptian civilization.

**Public Works in New South Wales.**—A sum of £10,000 having been voted by the Parliament for the improvement of the rivers Murray, Murrumbidgee, and Darling, active measures have been taken for carrying out the work. Clearing parties have been formed for cutting away and removing the snags and other obstructions that impede the navigation of the rivers. An extensive scheme of improvement is being carried out by the Engineer-in-Chief for Harbours and Rivers, and submitted to the Government. It is proposed to construct a range of wharves to enclose the whole of the head of Darling Harbour, with a view to the establishment of a railway terminus there, and in connection with it to deepen the whole of that part of the harbour to twenty feet, so that vessels of the largest class may lie alongside the wharves to discharge or take in cargo. In the event of this scheme being carried out, many of the large London ships with goods for the country would doubtless discharge at one of these wharves, where they would be enabled to transfer cargo from the hold into railway trucks without loss of time and immediate carriage; and they would also be in a position to take in, from the railway trucks, the produce of the country. It is the intention of the chiefs of the works department to have, if possible, all the more important public works in the colony photographed for the Paris Exhibition of 1867. This would undoubtedly be one of the most effectual means of exhibiting the importance of the colony, and the progress made within the last few years.
STAINCLIFFE CHURCH, YORKSHIRE.

(With an Engraving.)

The accompanying view shows the exterior of a church now
commencing at Staincliffe, in the parish of Batley, to supply
the wants of a new district. The architect is Mr. Crossland,
of Leeds, and the contracts, which are let out to different trades,
as is the local custom, will, with some additions, render the cost
of the work £7,000, £6,000 of which has already been raised in
the neighbourhood. The walls are of dressed stone, and the roofs
will be covered with Westmorland slate. The site, and a donation of £500, have been given by J. B.
Greenwood, Esq.

RECENT IMPROVEMENTS IN THE APPLICATION
OF CONCRETE TO FIREPROOF CONSTRUCTION.*

By Mr. J. Ingle.

Amongst the various methods of fire-proof construction as
applied to the floors, ceilings, and roofs of buildings, which
have been in use within the last twenty or thirty years, those in
which concrete forms the fire-resisting medium have been most
frequently adopted. The main reason for this preference, no
doubt, is that the horizontal form in which it is generally
disposed suits best the requirements of modern construction.

Brick arches, though used almost without exception to carry
the floors of the large fire-proof mills and warehouses of the
manufacturing districts, have disadvantages which almost pre-
clude their use in buildings of a more general or domestic
character. They require walls and girders of great strength
to sustain their weight and to withstand the outward thrust
which they exert, and the depth which they occupy on account of their
rise, when added to the board and joist arrangement above, and
the ceiling underneath, is so great as to involve a considerable
increase of height in the building to obtain the same clear space
between the floors and ceilings of the rooms. Of the systems of
fire-proofing in which concrete forms the chief element, that of
Messrs. Fox and Barrett is the one which has been most
extensively used.

It consists of a series of light rolled iron joists fixed 2 feet
apart, upon the lower flanges of which are placed filllets of wood
at intervals of an inch or an inch and a half. Upon these a mass
of concrete is thrown, the depth of the same being regulated to some extent by that of the iron joists, the concrete
being generally brought up flush with their upper flanges.
The whole is then paved, or covered with an ordinary wood
floor upon light sleeper joists. The underside of the floor
receives a second series of wood filllets nailed transversely to the
first, and at intervals of 12 in. or 16 in., and upon these the
ceiling is then formed in the ordinary manner.

The concrete used in this construction, in common with all
others in which ordinary lime forms an ingredient, is not strictly
speaking, a fire-proof body. The cementing material which
occupies the interstices between the fragments of stone or gravel
becomes, like ordinary mortar, in setting, a weak carbonate of
lime, and like the stone, from which it was originally burnt, is
reduced by calcination to a state of lime. This effect would
undoubtedly be produced upon any lime concrete which formed
part of the construction of a floor exposed to a severe con-
flagration.

The application of water to lime in the caustic state converts
it, of course, to a hydrate; and while undergoing this change it
assumes double its original bulk and falls to powder. The con-
sequences, therefore, which might naturally be expected to
ensue from the play of water from the fireman's hose upon concrete
floors in a calcined state, would be the overthrow or
fracture of the outer walls by their expansion. Some of the
numerous instances of the destruction by fire of buildings,
which were supposed to be secure from that danger, are
probably owing to this circumstance.

I have more especially alluded to this radical defect of ordi-
nary concrete as a fire-proof medium, because, in the system
which I am about to describe, a kind of concrete is employed
which retains its cohesion and a considerable portion of its
original strength, though water be thrown upon it while in a
red-hot state.

This method is a local invention, and is known as "Dennett's
fire-proof construction." I shall speak first of the composition
of the concrete, and then proceed to describe the manner in
which it is applied.

Gypsum, known chemically as the sulphate of lime, and
which is one of the most perfect non-conductors of heat, is the
most important constituent of the concrete, and is used in lieu
of the ordinary lime as its cementing material. This gypsum,
being unlike that manufactured into the plaster of Paris
which is used for ornamental purposes, undergoes a thorough
calcination. The latter is simply roasted in ovens, the finer
lumps of gypsum being carefully selected for the purpose. The
effect of this roasting is merely to drive off so much of the
water which enters into its chemical composition as to allow
the gypsum to be ground by millstones.

The rapidity of setting which is peculiar to this kind of
plaster is owing to the fact of its having but little water to take
up in order to resume a state of consolidation.

For the manufacture of the plaster used in Dennett's concrete
the coarser qualities of gypsum are used, such as in fact, except
for the subtilis, would be thrown aside as mere waste. The
inferior qualities are largely impregnated with clay, with the
beds of which it alternates, and this clay when burnt becomes
the very kind of material which is afterwards added artificially
in the mixing up of concrete.

Moreover, for this purpose any hard material possessing a high degree
of porosity is used: such as furnace drosses, olitic stone, or
broken brick. The latter being in most cases readily procurable
is generally used. It is necessary that all dirt and dust should
be carefully screened out so as to prevent the choking of the
pores of the brick.

The lumps of the plaster are first ground in a mill with the
water in which they are to be used, and the remainder of the
water is added when the plaster is thrown on the floors.

The space occupied by the gypsum in the finished concrete
setting, as a great amount of water is required to be taken up by
the plaster on account of its thorough calcination.

When the setting process is complete a degree of hardness is
attained, however, to which that of ordinary plaster of Paris
will bear no comparison, and which is equal to that of the best
cement bricks.

The form in which the concrete is generally applied to
the construction of floors is that of an arch, or series of arches, with
small rise. These are formed upon temporary centres, which
may be removed after an interval varying from two to six days,
according to the state of the atmosphere and the size of the arches.

Spans of from 60ft. to 120ft. can be bridged over in this manner,
the thickness of the arch varying from 3in. to 6in. in the crown,
and from 5in. to 10in. in the haunches. Rolled or riveted
iron girders form the intermediate supports of the arches, while
the outer haunches rest upon projections or corbel courses in
the brickwork. Floors of corridors and cottage rooms can be
formed, however, without the aid of any joists or girders
whatever. Of course the arch form presupposes a certain amount
of support from the abutments, but from the transverse strength
and thoroughly homogeneous character of the material very
little if any lateral thrust is exerted on the outer walls.

If a wood floor is required, sleeper plates and light joists and
boards are laid in the ordinary way; but if there is no necessity
for this kind of finish, or if it is desirable to make the upper surface
fire-proof, the haunches of the arches may be filled up to a
horizonal line and paved with stone, tiles, cement, or asphaltite,
and the latter being desired.

The cheapest and best kind of paving, however, is that which
may be formed by the concrete itself. To do this the porous
material is graduated in size until the surface can be finished
with the trowel. This surface can be executed in various tints,
and with different degrees of polish.

Second-floor floors the thickness of finish is particularly
adapted; it is cleanly, non-absorbent, free from vibration, and
therefore comparatively noiseless; and what is a very important

* Read at the British Association, Nottingham, 1860.
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RAILWAY ENTERPRISE IN ITALY.

In Italy there will be shortly working 5,335 kilometres, or about 3,271 English miles, of railway. Besides the completion of the Venetian lines, which will reach in a few days as far as the borders of Illyria, and 303 kilometres recently finished in the valley of the Tiber and the Arus, that is to say, Ancona, Orte, and Montevaccoli Torricella, within two months there will be opened to the public 317 kilometres of new line, namely, those of Pavia and Cremona, Brescia, Messina, and Catania, the completion of the Aretuna and Ferrara and Rovigo, which includes the temporary bridge over the Po. Within a month Florence will be directly united by railway on the one side with Rome and Naples, and on the other side with Venetia and the south of Italy; the pilgrimage of the Italian railways will begin to acquire a systematic character. They will have for basis two great lines without interruption; the one, 1,608 kilometres in extent, will traverse the peninsula Udine to Naples, by way of Padua, Ferrara, Podestia, Arezzo, Foligno, and Rome, and will cross at the Bologna station the other line, 1,200 kilometres in length, and which already unites Susa with Lecce, by way of Turin, Alexandria, Piacenza, Modena, Rimini, Ancona, Bari, and Brindisi.

ON THE CONNECTION OF PLATES OF IRON AND STEEL IN SHIPBUILDING.

By Nathaniel Barnaby, Assistant Constructor of H.M. Navy.

Much yet remains to be done to make iron shipbuilding a perfect art, and there is, perhaps, no one step remaining to be taken in the path of improvement more important than that of substituting a simple and efficient means of joining plates by welding, should it ever be discovered, for the present system of riveting. The loss of strength caused by the present system is considerable in iron, but almost negligible in steel. It forms, in fact, the great bar to the introduction of this most promising material into ships of war. As an illustration of this, one or two of the many experiments which have been made by the Admiralty at Chatham Yard on Bessemer steel of the best quality may be given. A piece of steel 4 feet long and 12 inches broad was cut from a half-inch plate, of which the proof strength was 33 tons per sq. inch. This piece was reduced to 5 inches in width at the middle, was supported at the ends by square plates riveted to it, and was carefully centred. The plate should have broken at 85 tons, and through the narrow part. It actually broke at 92 tons, and then, strange to say, broke through the wide part of the plate, tearing away through the rivet holes. Thus, while the material in the middle of the plate withstand a strain of 38 tons per square inch, it actually broke through the holes at 16-38 tons per square inch, or less than one-half the strain.

In a precisely similar plate, differing from the other only in the fact that the rivets connecting the end pieces were 1½ inches from the edge instead of 2½ inches, the plate broke in a similar manner at 78 tons, which is only 15 tons per square inch of the section of steel broken. The holes in both these cases had been punched, and in order to ascertain whether these curious results were due to the injuries supposed to result from punching, an exactly similar arrangement of plates was again tried, in which the holes were, as in the first, 2½ inches from the edge, but were drilled instead of being punched. The plate then broke through the narrow part at 103-75 tons, or 47-83 tons per square inch of the steel broken. I do not propose to draw here any inferences from the experiments detailed, or to enter into a series of which they form part, further than this, that all which I propose to advance concerning the necessity of bestowing greater attention on the comparative strength of different modes of connecting plates intended to give tensile strength, is even more applicable to steel than to iron. Admitting, then, that for the present at least, we must be contented to connect iron plate placed in holes punched or drilled out of the material, and, therefore, by the sacrifice of a considerable portion of the strength of the plate, it is manifestly the duty of the engineer and shipbuilder to study to make this connection with as little sacrifice of the tensile strength of the plates across the outer line of holes, of the butt strap or straps across the inner line of holes, and the resistance of the rivets to shearing, should be equal. Two plates may

TRACTION ENGINE.

A train drawn by a locomotive on the common roads has recently arrived at Paris. The locomotive has a tubular boiler, carries a tender, a water-tank, and foot-plate in front of the engine. The engine is on the top of the boiler; it has two cylinders, with reversing gear. It is worked from the front, by means of a high-speed axle, which is driven by one or two engines, with ease and perfect regularity; it can turn in curves of a very small radius, and can follow all the windings of the road. This engine, travelling on a level road, or on one that presents no gradients of more than three per cent., draws an actual load, after deducting the weight of the wagons, of twelve to fifteen ton and a half to two hours per hour. It draws at high speed, nine or ten miles per hour, a clear weight of from one to four tons and a-half. The wagons are coupled one to another as well as to the locomotive, by a mode of coupling which allows them to follow all the movements of the engine, however much it may deviate from the straight line.
be connected, for example, by butt straps, so as to reduce the strength of the plate by one hole only. The strength of the several parts has in this case been estimated on the assumption, verified by careful experiment at Chatham, that the shearing value of a ½ Bowling rivet, including friction, and taken either single or with others, is 10 tons, and that rivets of other diameters are in proportion to the squares of the diameters; also, that the tensile value of the iron between the holes is reduced in proportion to the number of the perforations, and that this reduction is about 25 per cent. when the holes are punched three or four diameters apart.

This double strap, if no value in shipbuilding, because the stringer and tie plates, to which it might otherwise be applied, have to be perforated between the butts by rows of holes to connect them with the beams. In such plates, in order to economize material, it is therefore desirable to reduce the amount of fastening at the beams as much as possible. I do not think it necessary to punch away for this purpose more than ¼ of the iron: the remaining strength of the iron would then probably be $\frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$ths of the whole, so that the straps connecting them should also give $\frac{9}{16}$ths of the full strength of the plates. Any greater strength at the butts would, of course, be thrown away. If the butt strap has to be caulked, this proportion would only be breaking it, and not be necessary, and that the beam should then be placed nearer together. I take, for example, the connection, by means of a butt strap, of two plates $\frac{3}{4}$ inches thick and 12 inches wide, in which the rivets are 1 inch diameter, and are spaced three diameters apart. Then we punch out $\frac{3}{4}$ of the iron, reduce the strength of the remaining fourth, and have left only $\frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$. The tensile strength of the plate at 20 tons to the inch is 180 tons, and the tensile strength through the holes about 90 tons. If the connection is made by means of a single strap, the value of the rivets will be about 71 tons; and if by a double strap, 142 tons. No appreciable advantage could be obtained from a second row of straps, nor would the spacing along the edge be increased. If the rivets are not nearer together than is necessary for caulkining, a second or third row could give no advantage, except in enabling us to reduce the thickness of the butt straps to less than the thickness of the plate, by reducing the number of rivets in the inner row, when the butt straps are obliged to break. None of these considerations are new, but they have been so much neglected that those who are familiar with them will justify me in thus restating them. But there are certain other considerations equally important, which have altogether escaped the notice of shipbuilders generally, we have not—the strength of the tie will be measured by the strength at the weakest place, and this strength is fixed. What I want to show is that this is not the case, and that we have overlooked an important element of strength, which is conducive to economy of material. Take the case of a stringer or tie plate crossing a number of beams, say 50 ft. 6in. apart, at each of which the strength is reduced to $\frac{3}{4}$ths of the full strength of the plate. If this plate is brought under the action of a steady strain it is a matter of indifference practically how many such points of weakness there may be, and how much stronger the material may be lying between the weak points. But when strains are suddenly applied, we have to consider not only the number of tons required to break the weakest section, but the amount which it would stretch before breaking. It is, in fact, the work done in producing rupture, viz.: the force applied, multiplied by the distance through which it acts, which is the true measure of the resistance to rupture. Under these circumstances no elongation will take place in the plate between the weak points; it will all be thrown on the weak points; and if any one of these be weaker in any sensible degree than the rest it will be confined to that point. This being the case a large increase of power may be obtained by reducing the strength of the plate between the weak points to the strength at these points, or even so less than this, provided we get long spaces of uniform strength to give elongation.

To illustrate this I will refer to some experiments made at Chatham with armour bolts, with reference to a proposal of Captain Palliser's. The proposal was to apply to armour bolts, having screws cut on them, the well-known principle that the bolts would be strengthened at the screw thread, and become singly capable of breaking out under a jar, if the bolt, or a portion of it beyond the thread, were reduced in section to the same area as the iron left uncut at the thread.

The experiments referred to, made under my own careful observation, showed—

1. That iron bolts of good quality and of uniform diameter, subjected to a steadily increasing strain, elongate before breaking about one-fifth of their original length.

2. If the diameter is not uniform, but is decreased through a portion of the length, then the reduced part elongates about one-fifth of its length before breaking, and the larger portion scarcely stretches at all.

3. If this reduced part is very short, as in the thread of a screw, the strain required to break the bolt, is the same per square inch of the unstretched or original section as in the previous cases, but there is scarcely any elongation before rupture.

4. If the whole length of the bolt is made to the reduced diameter of the screw thread, so that the thread projects from the main body of the bolt—broadly speaking, the thread is the same as before, but as the bolt will stretch one-fifth of its length before breaking, it becomes thereby less liable to rupture by a sudden blow, because, as already stated, the work done in producing rupture is in proportion to the weight or strain applied, multiplied by the elongation or the distance through which it is applied.

The details of one portion of these experiments were as follows:

Four bolts were taken, all made of best selected scrap iron, for the purpose of the experiment, and all of the same diameter, viz., $\frac{3}{4}$ inches; screw threads were cut in the ends of these, and nuts fitted. The other ends were formed with heads leaving a length of 21 inches between the heads and the nuts. The four bolts being thus as nearly alike in every respect as they could be made, two of them were reduced down on the unriviled length of $\frac{3}{4}$ inches in the middle of their length, to a diameter of $\frac{1}{2}$ inches, which was the same as that of the iron remaining within the screw threads. The two other bolts retained the full diameter throughout. They were broken in the hydraulic press, with the following results:

| Breaking | Tons per in. of Elongation. |
|---|---|---|
| Strain | in. | broken, this sec. | in. | in. | in. |
| Bolts not reduced | | | |
| No. 1 | 63 | 276 | 22.8 | Nil | 1 1 1 At thread |
| reduced | | | |
| No. 1 | 69 | 276 | 25.0 | Nil | 1 1 1 Same Ditto |
| Bolts reduced | | | |
| No. 2 | 66.5 | 207 | 38.33 | $\frac{1}{2}$ | 1 1 1 In reduced part |

The fact that the strains of greatest magnitude in a ship are sudden in their nature, makes the principle under consideration of no slight importance, because we see that by its application we are able to increase the time during which a given force must be applied in order to produce rupture. As the material is disposed at present in iron decks, and stringer and tie plates, the plates are perforated in the lines of the beams, not only by the bolts required for the rivets to secure them, but also by the deck-bolts which secure the wooden deck lying on the iron plating. The loss from the iron punched out, and the weakening of that which remains, amounts, on the whole, to from 30 to 40 per cent. of the original strength of the plates. These lines of weakness occur at intervals of about 3 feet 6 inches, and between them the plate has its full strength, except where a butt occurs.

The consequence of this is that when the deck is put in tension, the stretching is confined to these weak places, and the amount of work of which the whole combination is capable of doing before rupture is extremely limited. In order to remedy this state of things, I propose to remove all the wooden deck fastening from these weak places, and put it on either side of the beam. The number of rivets for attaching the plating I also propose to reduce. By this means a strength of plating is obtained across
the lines of riveting of about three-fourths of the full strength of the plates. The next thing to be done is to reduce the strength of the plating between the beams to the same amount. This might be done by cutting holes in the plates; but instead of doing that, I propose to make the rivets of the beams so that in each of these spaces there shall be a continuous series of butts and plates, in the proportion of one butt for every three plates. In addition to this reduction of material, I propose to leave intervals between the butts of about one-third the distance between the beams, so as to get long spaces of unbroken plating between the beams.

The length of the intervals between the butts will be determined by the number of rivets which can be placed in the edge of the butted plate between the beam and the butt, as there must be sufficient to break the plate across the beam. A short piece of edge strip on the under side doubles the shearing value of the rivets, and allows about one-third of the distance between the beams to be admitted. The advantages of one system over the other are, I think, the following:

1. In the ordinary system one-fifth or one-sixth of the iron is punched away; by that proposed only one-ninth or one-tenth is punched out. There is from this cause a gain in direct tensile strength, which must be added as an increase of strength in the iron between the holes. These are together equal to about 12 per cent.

2. The strength of an iron deck under compression is limited, not by the area of section, but by its resistance to buckling between the beams. According to the ordinary mode of riveting, the stress is small, since it is quite free to bend downwards between the beams. But by spacing the deck fastening, as shown, at intervals of about 2 feet instead of 3 feet 6 inches, the tendency to buckling would be reduced. The wooden deck would thus, both by its own direct resistance to compression, and by the support it gives to the plates, play a most useful part in compression, although it is powerless as against extension when in connection with iron. I therefore conclude that no loss of compressive strength is incurred by the holes in the plates.

3. All the holes for receiving the deck fastening may be punched, whereas if the fastening is in the beam flanges, the holes for them must be drilled either in the plates or in the beams.

4. The expense of cutting, fitting, punching, and rivetting butt straps is avoided. Where the material employed is steel, the gain is more considerable, as all the holes in the butts of the plates and in the straps have to be drilled to prevent the injury done by punching.

5. The weight of material admitted at the butts amounts to one-seventh of the whole material employed.

6. There is a gain in strength against injury and rupture by the action of sudden forces, the amount of which is not susceptible of calculation, but which, being in proportion to the extent of the spaces of uniform strength which have been introduced, is, I think, very considerable.

The novelty of this proposal may be said to consist in so arranging the iron or other metal plates forming the flanges of girders, bridges, and other structures, or employed in decks, partial decks, stringers, or ties in a ship or vessel, as to make the tensile strength of the unperforated plates, intervening between adjacent butts, equal or nearly equal to the strength of the said intervening plates taken together with that of one of the butted plates where they are perforated, i.e., across the row of holes made for the purpose of attaching the plates to the beams, angle irons, stiffeners, or other iron framing, and by this means rendering the use of butt straps in such combinations unnecessary. In other words, a section through the plates between the beams or stiffeners is made to have, without butt straps, about the same tensile strength as a section through the fastening at the beams or stiffeners, for the purpose of forming spaces of uniform tensile strength greater than that of the weaker part of the combination. In these intervals elongation will take place to an extent depending on their length before the materials can be ruptured, so that an increased amount of work will require to be done by the operation of a given strain in producing rupture. Also, in increasing the resistance to rupture under sudden strains in the plate by reducing the tensile strength throughout certain intervals between the beams, angle irons, or stiffeners, and approximating to that at the beams, angle irons, or stiffeners, by cutting out portions of the plate.

I am aware that iron decks are not used in merchant vessels, although they are in all iron war ships built for the Admiralty, and I consider it to be false economy to substitute, for such decks or partial decks, stringers on the ends of the beams, tie plates near their middle, and diagonal plates between them; as I think it clear that from the round up of the beams, and other causes, a considerable portion of this material is unable to succour the rest when the top of the ship is put in tension or compression. The strength of wrought iron in extension and in compression is about the same, yet the bottom of the ship is usually made enormously stronger than the top. Some iron ships, indeed, have no proper top, or only a wooden one. Much of the strength of the bottom, which might otherwise be made available in giving strength to the ship, considered as a floating girdler, is thus wasted.

I hope that the economical considerations pointed out may be not only useful in lightening and strengthening ships designed for war, but in inducing private shipbuilders to introduce partial iron decks, so formed, into ships designed for commerce. These proposals do not form the subject of any patent.

THE PARISH CHURCH, BIRSTAL.

(With an Engraving.)

BIRSTAL, a place of some importance a few miles from Leeds, has a large parish church, upon which the work of restoration and enlargement has been enlarged. The plan is unusually large, and consists of nave and chancel, with an aisle on each side extending the whole length of the building, while an extra aisle on each side occupies the length of the nave only. A small tower, situates within the building, rises from the west end. The style of architecture partakes largely of the "Perpendicular," but in the new features the "Decorated" style has been followed. This is particularly observable in the aisles and clerestory windows, which are being reconstructed. The chancel is of very "Late" character. The architect to whom the restorations are entrusted is Mr. W. H. Crossland, of Leeds.

THE WORKS ON THE MONT CENIS TUNNEL.

BY THOMAS SOPWITH, jun., C.E.

This tunnel is to be the completing link of the Victor Emmanuel railway, which will put France in direct railway communication with Italy, and place Turin within eighteen hours' journey of Paris. In June, 1869, the railway was opened on the French side to St. Michel, in Savoy, and on the Italian side to Susa, in Piedmont. Modane, near to which is the French, or north entrance to the tunnel, is about 10 miles from Susa, on the "grande route" to Turin. Thence the tunnel will pass under the Col de Frejus, about 18 miles west of the actual Mont Cenis, coming out in Italian territory near Bardonnèche, about 24 miles from Susa. The traffic is at present conveyed by St. Michel to Susa, a distance by road of about 50 miles, by the "grande route" originally made by the first Napoleon, and known as the Mont Cenis pass, the lowest of the Alpine passes. When the tunnel is finished, it is not unlikely that postal communication and traffic with India may be advantageously transferred from Marseilles to some Italian port. By referring to a map it will be observed, that the line of rail is nearly straight from Paris to Macon, Oulx, and by the tunnel, to Turin; it afterwards continues by railways already opened, or in course of construction, to Ancona, thence to Brindisi, on the east coast of Italy. A north-west wind prevalent at Marsala, and in the Mediterranean, more particularly during the winter months, makes that port extremely difficult, and sometimes obliges the captains of steamers to abandon the direct line from Malta, and to keep along the coast by the South of Sardinia and France.

* Paper read before the Institution of Civil Engineers.
The advantages that might be expected to arise, from the establishment of railway communication between Italy and the rest of Europe, have not been underrated; and Italian engineers, for more than twenty years, considered various projects for the purpose. Great difficulties were met with in the selection and the proposed routes, that selected seemed to be the most feasible; and, indeed, it was only a question whether the mountain should be crossed by a series of inclines, with engines specially adapted to them, or whether a tunnel should be constructed.

In 1867, M. Sommeller, Grandis, and Grattoni, engineers, who had engaged the work from the beginning, and who were then engaged upon other works in which compressed air was employed, brought before public notice a plan for using it to drive machinery for replacing the ordinary method of boring by hand-labour. Experiments, at the expense of the Italian Government, were made near Genoa with machines on this principle, and with compressed air as a motive power. These were so satisfactory that a Commission was appointed to examine how far these machines were applicable to the proposed tunnel, as well as to ascertain if there was sufficient water-power for compressing the amount of air necessary for working them. An abundant water supply has been found to exist at each end of the proposed tunnel, and the report being agreeable to the project was accepted, and, pending the construction and erection of the machinery, a commencement was made, at both ends, by ordinary mining, in the beginning of the year 1868. A careful examination of the geological features of the district showed that no particular difficulties were to be apprehended in the rocking of the rocks. The air, the projectors, being sanguine that, by the aid of machinery, the time which would be required to make it by ordinary means could be greatly reduced, the work would perhaps never have been undertaken, as, judging from the usual rate of progress in such cases, it must have required from thirty to forty years to complete it. And when mention is made of the ventilation, the air being drawn from a source a thousand feet above the line of the tunnel. The ordinary difficulties of making a tunnel 7½ miles in length are in this case much increased, on account of the impracticability of sinking shafts on the line to ventilate it; and its progress must necessarily be slow for the same reason, only two points of attack have been made. After being sanguine that, by the aid of machinery, the time which would be required to make it by ordinary means could be greatly reduced, the work would perhaps never have been undertaken, as, judging from the usual rate of progress in such cases, it must have required from thirty to forty years to complete it. And when mention is made of the ventilation, the air being drawn from a source a thousand feet above the line of the tunnel.

The Author never entertained any apprehensions on that account, as the ventilating current in many coal-mines passes over a longer distance, and far exceeds in quantity any possible requirement of the Mont Cenis; and, by the introduction of two horizontal or vertical brattices, the tunnel may be placed under the same conditions as many parts of a coal-mines. It would have been almost impossible to employ any other power than compressed air for working the machines in the 'forehead,' which affords, after its escape, a supply of fresh air to the workmen, and by expending from a greatly reduced bulk to its original volume, and consequent absorption of heat, the temperature, when the men are at work, is considerably reduced, seldom exceeding 70° Fahr. It is also readily applicable for general purposes, and small engines for pumping, &c., are driven by it.

Gas made at the surface, is used for lighting the works, and at Bardonèche the height is increased 1½ inches, and the pressure is added in the machines in the great mass of the strata, the exact length between the ends is 7,593 miles, or 7 miles, 4 furlongs, 7 chains, 9 yards. The present ends will not, however, be the actual entrances when the tunnel is finished. To avoid sharp curves, the line will leave the tunnel about 415 yards from the start, and will unite with the main road at the beginning of the strata. The tunnel at Modane is built entirely with stone; at Bardonèche the side walls only are of stone, the arch, with the exception of 327 feet at the beginning, being of brick. The northern entrance, at Modane, is at an elevation of 3,940 feet, and the Southern entrance, at Bardonèche, of 4,379 feet, above the sea. There is a difference in level therefore between 434 feet between the ends. On this account the tunnel will leave Modane with a rise of 22½ per 1,000, or about 1 in 454, and it will continue so for half its length, when it should attain the elevation of the roads from Bardonèche, which are made to rise towards the middle of 0·50 per 1,000, or 1 in 2,000 only. The highest point on the surface in the line of section is 9,250 feet above the level of the sea. When once the work is completed it is expected that there will be a constant draught of air from the mouth, as the latter is not only higher and the air more rafed, but it is exposed in a greater degree to the heat of the sun.

Before proceeding to state the rates of progress made by the ordinary means, and those obtained since the introduction of the machinery, the Author will give a brief description of the system of tunnelling pursued at Mont Cenis, as a general idea of this system is indispensable for the appreciation of the statements which will shortly be made; and he will reserve for subsequent consideration more detailed notices of the machines employed. The establishment at each end of the tunnel consists of machinery for compressing the air, workshops for making and repairing machinery, offices, storehouses, residences for the engineers, barracks for the workmen, forges, &c. At Modane the entrance is about 328 feet above the bottom of the valley, up which the railway passes, and where the workshops are placed. The railway, to gain this elevation, makes a 'détour' up the valley. The entrance is, however, in direct communication with the shops, by an inclined plane, with two lines of rails, worked by a water-balanced, the inclination being about 30°.

Experiments and attempts have already been made, both in England and in America, with a view to introduce machinery for tunnelling, but never with complete success. In England a tunnel was introduced by Colonel Pilkington, B.E., was made at Newcastle upon Tyne, and was afterwards used by the Ebbw Vale Iron Company. It was intended to bore a gallery about 44 feet in diameter, by means of a frame with six radiating arms, or ribs, finished with cutters fixed on a shaft under maximum pressure of one hundred strokes, or blows, per minute. By this system the whole of the material extracted would be in the form of chippings and coarse grains, and in thus reducing it to so small a size, much unnecessary work would be performed. Any means of tunnelling by machinery, in which the power afforded by steam pressure, and the elevation of the strata, and the work still to be economical. M. Sommeller's system has the great advantage of using it. His object has been to apply machinery to bore small holes to receive the charges of gunpowder, and to do this in less time than can be accomplished by hand labour. This has been effected by mechanism of very ingenious construction, and composed of two horizontal or vertical rotary engines, and its duty is to work the valve of the larger cylinder, to advance or withdraw the latter on its frame as may be required by the increasing depth of the hole, or to allow of the borer being replaced, and, finally, to give a rotary motion to the borer itself. The other machine comprises a larger cylinder for propelling the tool, or borer, against the rock, the tool or borer being a direct continuation of the piston rod. The piston rod is large, and a constant pressure is kept on the annular surface of the piston, to return it after each propulsion, without the use of a valve with double action. The air for driving these machines at about 6 atmospheres above atmospheric pressure, and each machine makes two hundred and fifty strokes per minute. The pressure on the piston in striking, deducting that required to overcome the constant pressure on the other side, is 216 lbs. Calculated by the pressure of the air, and the number of feet travelled by the piston per minute, the power is 208, as the Author believes to be the case, that the compressed air is not used expansively, or cut off before the end of the stroke. The length of the stroke may be varied from 2 inches to 7½ inches, and the diameter of the cylinder is 2½ inches. Each of these machines weighs about 6 cwt. A stock of the machines is kept on hand to replace those that are worn out. The Author is of the opinion that, although simplified as much as possible, the machines are still liable to frequent derangement. On an average, after eight or ten 'shifts,' or, say, after boring from sixty to eighty holes, a machine needs repacking, and perhaps
the replacing of some working part. It may not perhaps be too much to say, that four machines must be kept in reserve for one that is working. The cost of each machine is about £20.

A strong iron frame, weighing with the apparatus it carries 18 tons, provided with rails, crossbars, adjusting screws, &c., moves on rails close to the 'forehead,' and on it are fixed the machines. Each machine can be made to work at almost any inclination; but as, in doing so, it is likely to interrupt the efficient working of the others, the holes may practically be considered as being bored nearly horizontally, an increased number making about any loss in the output of their not being so, still placed as they might have been. This is not so great a disadvantage as it may appear at first sight. Miners consider it of great importance that the holes should be so situated as, when exploded, to lead to the destruction of the largest quantity of matter. It is, however, of equal importance at Mont Cenis, that the rock brought away should not be in large pieces, as a longer time would then be required to remove them, and possibly in some cases, the pieces might have to be again broken up by blasting. The frame carries at Modane eleven machines, and at Bardonnèche nine machines. The size of the advanced gallery is about 10 feet square: but an experiment is being made with a gallery of 7 feet square, in which case the necessarily smaller frame can only carry 7 machines. If this is successful the system will be much more practicable, and will be an important consideration for mining proprietors; as the original size of 10 feet square, if indispensible to the efficiency of the machines, is too great for ordinary mining galleries. Behind the frame there is nothing resembling a vessel filled with water which is kept at a pressure of about 5 atmospheres, by being in communication with the compressed air, and is used for the jets, one to each machine, which keep the tools cool, and remove the borings. The air is conveyed along the tunnel in pipes about 2½ inches in diameter. Some distance from the 'forehead' a caoutchouc pipe conveys it to a small reservoir on the hinder part of the frame, from which it is taken by caoutchouc pipes, about 2 inches in diameter, to each machine.

Each time of working, or 'shift,' about eighty holes are bored. When these are completed, the frame and machines are withdrawn, and the charges and fires are again relieved by others, who remove the rock shot down. The division of time amongst them is very variable. It may, however, be assumed as from 6 to 8 hours for the machinist.

1/2 to 2 charging and firing. 3 or 4 working 'déblais,' or hardly two complete 'shifts' every twenty-four hours. In June, 1853, during twenty-seven working days, forty-six 'shifts' were worked; except, as in June, when there was a 5½ more than usually popular amongst the workmen, and when the works were suspended for three days, for the Fête d'Italie, the works are done during day and night, without interruption, 5 days included. An alignment is made once in three months, from an observatory at each end. As yet no error has been detected.

The frame is provided with an engine, worked by compressed air for advancing it into, and withdrawing it from, the 'forehead.' At the completion of a 'shift,' it is withdrawn from 50 yards to 100 yards, to the shelter of some sort of cave, removed from time to time as the 'forehead' progresses. When it is again required, it can be taken to the 'forehead' in two or three minutes; owing to the length of borers used, 6 feet is quite near enough, and once there, little time is required for setting the machinery to work; within 10 or 12 minutes, two or three haps are in operation, and in ten minutes nearly all. Three or four large holes 3½ inches in diameter, are bored about the middle of the 'forehead,' the remainder are about 1½ inch diameter and 2 feet 8 inches to 3 feet deep. The larger holes are the same depth, but are not charged, their purpose being to ease the burden to be levied on the rest of the explosions. The holes round these larger ones are the first charged and fired, making a cavity in the middle, or 'laying in' as it is called by miners. The remainder are exploded in turn from the cavity onwards. The workmen—Piedmontese for the most part—are hardy and courageous under circumstances which require more than ordinary coolness and courage. A premium is paid in a premium upon more than a certain advancement per day in the advanced gallery. The distance on which the premium is based varies with the nature of the rock. The standard is now 1 metre per day.

For 1½ metres 1½ day's wages are paid

\[\begin{array}{c|c|c|c|c|c|c}
1 & 1½ & 2 & 3 & 4 & 5 & 6 \\
\hline
1½ & 1½ & 1½ & 1½ & 1½ & 1½ & 1½ \\
\end{array}\]

This is reckoned and is subject to adjustment every fortnight.

For removing 'déblais' produced by explosion, there are two lines of rails at Modane, one on each side of the line which carries the support and the machines. It is removed in small waggons to the end of the advanced gallery, is there tipped into larger waggons, and is thence taken by horses outside the tunnel.

The removal of the products of explosion is very well organized, and could only be improved by a system of removing on train, which would be difficult to carry out. It may be possible, however, to construct an iron frame running on rails, to be placed at the 'forehead' at the time of explosion, which would receive the greater part of the products of explosion, and this is now under consideration. Much time would be saved if such a system were practicable.

Before giving some data as to the number of men employed, that place, in, not having water available at a sufficient pressure, although there was an abundant supply at a lower level. M. Sommeller therefore carried out the singular idea of using the same machines as at Bardonnèche, to avoid the additional cost of constructing others of different dimensions, although in doing so he was obliged to erect a large cistern, near the machine house, 80 feet above the machines, as at the other end are ten machines of the kind about to be described. Each machine communicates by a pipe, 24 inches in diameter, with the reservoir of water above, as also with a wrought-iron vessel, of boiler shape, and about 610 cubic feet capacity, one being attached to each machine. The air is compressed up to 6 atmospheres above the atmosphere pressure. The compressed air introduced into the reservoirs is kept at a constant pressure of 5 atmospheres by a water pipe from a reservoir with that pressure. A pipe, 7½ inches diameter conveys the air from the reservoir to the tunnel. The joints of this pipe are very tight, being turned and a copper ring running on each. The pipes rest on rollers, carried on stone pillars, and expansion joints are introduced occasionally outside the tunnel, where the temperature is variable.

This system of compressing air (à coup de belier) is also established at Modane; but there was a further difficulty at that place, in not having water available at a sufficient pressure, although there was an abundant supply at a lower level. M. Sommeller therefore carried out the singular idea of using the same machines as at Bardonnèche, to avoid the additional cost of constructing others of different dimensions, although in doing so he was obliged to erect a large cistern, near the machine house, 80 feet above the machines, as at the other end are ten machines of the kind about to be described. Each machine communicates by a pipe, 24 inches in diameter, with the reservoir of water above, as also with a wrought-iron vessel, of boiler shape, and about 610 cubic feet capacity, one being attached to each machine. The air is compressed up to 6 atmospheres above the atmosphere pressure. The compressed air introduced into the reservoirs is kept at a constant pressure of 5 atmospheres by a water pipe from a reservoir with that pressure. A pipe, 7½ inches diameter conveys the air from the reservoir to the tunnel. The joints of this pipe are very tight, being turned and a copper ring running on each. The pipes rest on rollers, carried on stone pillars, and expansion joints are introduced occasionally outside the tunnel, where the temperature is variable.

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and Italy, on the acquisition of Savoy by the former country, when nearly half the section of the tunnel became French territory; but the Italian Government undertook the responsibility of finishing the whole of the works.

The Author has twice had the privilege of visiting the works on the Mont Cenis. The first time was in the autumn of 1868; the second was in July of 1869. At the date of his first visit, machines had not been applied at either end. The machinery was first applied at Bardonnèche, in the beginning of 1861, and at Modane on the 26th of January, 1863. As before stated, the tunnel was commenced by ordinary means in the beginning of 1866.

The following are the rates of progress in the advanced gallery:

MODANE.
Hand labour.* From 1868 to end of 1862, 5,615 feet per day.
Machine work. From January 26th, 1863, to June 30th, 1863, 166 days, but 163 working days only, advancement of 171.95 metres = 1,119 metres, or 3,986 feet per day.

BARDONNECHE.
Hand labour. From 1858 to end of 1860, 3 years, driving 724 metres = 6612 metres, or 2,418 feet per day.

The introduction of machines in 1861, but little progress was made, owing to the breakage of compressing machinery (170 metres about). In 1862 there was an advancement of 389 metres = 1,040 metres per day, or 3,411 feet per day.

The following notes of advance at Modane were copied from the shift book of the Mining Engineer, in which every detail relating to the progress made is entered, and afterwards tabulated:

<table>
<thead>
<tr>
<th>Date</th>
<th>Progress (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1863, January 26th</td>
<td>429.5</td>
</tr>
<tr>
<td>Feb 28th (38)</td>
<td>283.1</td>
</tr>
<tr>
<td>March 31st (41)</td>
<td>341.4</td>
</tr>
<tr>
<td>April 30th (30)</td>
<td>314.2</td>
</tr>
<tr>
<td>May 31st (31)</td>
<td>388.0</td>
</tr>
<tr>
<td>June 30th (27)</td>
<td>383.5</td>
</tr>
</tbody>
</table>

January and February apart, when the men were unaccustomed to the new work, it seems that the rate of progress was 2,036 metres, or 3,353 feet per day, and taking June alone, 1,439 metres, or 4,719 feet per day. In June there were 46 shifts; the average progress per shift must then have been 3845.5 metres, or 2,769 feet. Comparing the progress made from 1858 to 1863 by hand labour (9047 metres per day), with that obtained during the entire time the machinery has worked (1,119 metres per day), the latter is in the proportion of 1:9.17:1. Or, what is fairer, considering the disadvantages the machines labouring before the workmen were disciplined in their use, taking the progress in January and February apart, 1,436 metres per day; the proportion is 2:39:1, and taking June only, 1,430 metres per day 2:86:1, or nearly 3:1 to Modane. The above progress was, both in the case of machine and manual labour, in a gallery 10 feet square, 11 machines being employed, of an aggregate force of 2647 H.P., estimated by the ordinary rule applied to steam engines.

Probable Duration of Work.—June 30th, 1863.
1,295.25 metres had been pierced at Modane
1,459.00 Bardonnèche
2,542.25 ' in all
9,777.75 ' yet to complete
12,320.00 metres.—Total length of tunnel.
Assuming the progress to be as in June last, at the rate of 1,439 metres at each end, 9 years 2 months will be required from June 30th, 1863. In view, however, of the greater facility with which the machines will be worked when the men are more habituated to them, and of better results when their power is increased, as is now proposed, and their construction and application simplified, although quite aware of the increased difficulties to contend with as the ‘forehead’ advances, the Author thinks it prudent to say that an average part of 1,430 metres per day will shortly be made at each end. A great delay is now caused by the length of time required to remove the ‘déblais.’ If indeed a system were introduced for removing the ‘déblais en masse,’ instead of by small wagons, then 60 shifts might be worked per month, and 1,200 metres would be made, instead of 1,430. That rate for each end would require 6 years 7 months only, compared with 24 years 3 months at the rate (5047 metres per day) made at Modane before machinery was introduced.

The advanced gallery is enlarged to full tunnel size, and walled by ordinary means. A conduit is made between the two lines of rail, for drainage. Any favourable judgment on the results obtained at the Mont Cenis must be modified by the consideration of the enormous cost of establishing and working the present system at that place, as well as the large number of workmen required. Of the cost of the establishment it would be difficult to make even an approximate estimate. The machinery was nearly all made at Seraing, near Liége.

The expense of applying M. Sommeiller’s system depends, necessarily, very much on local conditions. And although ignorant, as he has already said, of the cost of establishing and working it at Mont Cenis, the Author will endeavour to institute a rough comparison, between the cost of the work undertaken by machinery and by hand labour. In this he is greatly assisted, by having been able to obtain some information about the number of men employed under the present system, which he believes to be reliable. As first in importance the men in the tunnel will be enumerated. In the advanced gallery at Modane, the machines work a shift of 8 hours, and are relieved by charges, who in turn are replaced by men to remove the déblais. A second set of machinists follows the latter, but the same charges and labourers serve, their work not lasting long. There are therefore 2 sets of machinists, 1 set of charges, and 1 set of labourers. The machinists for 2 shifts amount to 88, or 24 per shift. The changes to 9 per set. The labourers for removing the déblais to 30, making a total of 127 in the advanced gallery.

For enlarging the tunnel there are three sets of miners per twenty-four hours, and two sets of masons, all working eight hours, in number amounting to 254, or 17 per shift, as already enumerated, making a total of 471 employes underground. There are, however, stone-dressers, quarriers, blacksmiths and labourers at the surface to be taken into account, increasing the number at the tunnel and entrance to 700. The establishment below, workshops, machinery, canals, &c., afford to about 340 employes, or 11 per shift, making the total, as indeed nearly always, from 150 to 200 were employed as ‘occasional’; total for Modane 1,140. The number was rather greater at Bardonnèche, from 1,300 to 1,400 being generally employed, giving a total of 2,540.

In making a comparison of the cost of driving an advanced gallery by machinery, and by hand labour, a judgment must not be altogether based upon the works and the results at Mont Cenis. There is no doubt that establishing, as M. Sommeiller has done, on so large a scale, an entirely new system, without experience in its use and application, many expenses have been incurred, that would be avoided hereafter.

The following comparison will, therefore, be general to any work on a sufficiently large scale to justify the adoption of machinery, rather than special to the Mont Cenis. The data are insufficient to enable the calculation to be made with accuracy, but it will be based on statements already made. It will be confined to mining charges only, i.e., labour, tools, gauntlets and candles. Removing the déblais is common to both, as is also enlarging and walling the tunnel, and timbering the advanced gallery. The rate of progress of the gallery at Modane, which is ten feet square, will be taken into consideration; but the Author feels certain, that in a 7-foot gallery the machinist would compare with hand labour to better advantage. Previous to the introduction of machinery the miners drove, on an average, 1,655 feet per day; 38 men in three shifts
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

[October 1, 1868]

of 12 men each being employed. This advancement would then cost—

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost per day</th>
<th>Per advance of 1,665 ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 miners at 2s. 6d.</td>
<td>£4</td>
<td>0</td>
</tr>
<tr>
<td>Tools, gunpowder, and light</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>

Cost per day and per advancement of 1,665 ft. £6 0 0

or £10 17s. per yard.

It is hardly necessary that the Author should allude to the small portion of the total cost, of either advanced gallery or tunnel, expressed by ‘mining charge.’ To compare, in like manner the cost of driving the same gallery by machinery, it will be necessary to take—

1. The cost of motive power for compressing the air to drive the perforators.

2. The working charges of shops to repair the machinery, in excess of what would be required if no boring machines were used.

3. Men employed: mechanics, blacksmiths, &c., in such shops; as also engineers and stokers, and those to attend to air-pipes, water supply, engine for pumping water, &c.

4. Men employed during the machine shift.

5. Wear and tear of machinery, and many other incidental expenses, which in a fair comparison, would require full and careful considerations, and would vary according to local conditions.

The points on which this comparison is based are stated, to show how the proportional cost has been arrived at: the Author has only made it, in the hope that the attention of the members of the Institution may be drawn to its better consideration. As wear and tear alone can be obtained in exceptional cases, steam will be assumed as the motive power for compressing the air used for driving the boring machines. At the rate of driving practised last June, a mean progress of 2,769 feet per shift was made. The labour of miners and machinists would amount to £4 14s. 6d. per shift, and say, £3 10s. for gunpowder, tools, and light, amounting to £8 4s. 6d. per shift and advancement of 2,769 feet, or £8 18s. 4d. per yard. Eleven machines were used, expending in compressed air a power of 286 horses at the end of the gallery. Each machine, however, requires a motive power in the system of compressing applied at Bardonnette of 5 H.P.; but as they are not working continually, a constant power of 40 horses would be sufficient to supply them. Assuming that the motive power was steam, and that 4 tons of coal per day were consumed, at 10s. per ton, say £2, and the wages of engineers and stokers cost 15s. per day, there would then be for cost of motive power per day.

About 240 men are now employed in the shops and about one, would be required, to half of one, say £2 15 0

And calculate for steam power to drive machinery, &c., for coal and attendance per day.

Wear and tear on machinery, say 20 per cent. on £20,000, say per day.

Cost per day and per advancement of 4,719 ft. £275 15 0

Or £17 12s. 9d. per yard at the rate accomplished in June, 1868, which, added to the mining charge of £8 18s. 4d., would amount to £20 11s. 1d. per yard, as compared with £10 17s. by hand labour. From which it appears, so far as may be judged from so rough an estimate, that by machinery a progress three times as fast as by hand labour may be effected, at least at two and a half times the cost. For mining charges, in the case of a gallery for mining purposes, the comparison might stop there; but not so in the case of a railway tunnel. For the enlarging, timbering, walling, and general charges would be entitled common to both, and the proportion will be notably diminished when they are added. The estimated cost of making the Mont Cenis tunnel was £120 per metre. It makes but little difference, therefore, whether the mining charge there is £10 or £23 per yard. The ultimate proportion of cost to put against an increased advancement of this nature, will only be known by the experience of the great inventions of the past and present age—by the untiring perseverance of those, whose interest or ambition it is to devote themselves to its accomplishment, and by continually encountering and overcoming the many and great difficulties which oppose it. Attention must and will be drawn to it; for with the enterprise of this age, the necessity will be felt of improving the present system of tunneling. That necessity right felt, the means will not be long in following.

(To be continued.)
THE HYDRAULIC LIFT GRAVING DOCK.*

BY EDWIN CLARK, M. Inst. C.E.

(Continued from page 260.)

Mr. W. B. Eipingdale had watched the progress of these pontoon docks with interest, and thought that great credit was due to the Author for the perfect way in which he had brought hydraulic lifts to bear so successfully upon such enormous weights. The pontoons were, however, somewhat defective, as it was impossible to render them perfectly rigid, without making them so heavy that it would be impossible of use. When a pontoon was 300 feet in length, and only 6 feet in depth (which was in proportion of only 1 to 50), to make it rigid so much metal must be inserted as to sacrifice altogether its floating power. He remarked that the original pontoons, which were built for direct use on a ship, a deflection of 7 inches or 8 inches out of the straight line. Reference had been made to the pontoon sunk at the London Docks, with which he had had to do. He believed the construction of that pontoon to have been perfect, although it had failed at present. The side girders were 180 feet long, 17 feet deep, and 3 feet wide. A ship might be put upon the deck between the girders without injury to her straight line. He attributed the sinking of that pontoon chiefly to the want of compartmentation and stiffness in the large spaces between the girders, which were 8 feet apart. She was built like a long flat teak-board. The water went in at one end, and there was a consequent depression of that end. This caused an almost instantaneous rush and accumulation of water to one spot, the parallels gave way under the violent strain, the water washed through, and the ship went down rapidly at one end, whilst the other was some hours in sinking. Pumping at the rate of 26 tons per minute, had not the slightest effect in reducing the water; and it was not until this great pumping power had been used, that the water could be removed, when the whole effect of the blow was blown off. With regard to the pontoon docks in these two instances, it seemed to him a great waste of money to construct them in a tidal river, in order to do artificially, that which could be done naturally by the rise and fall of the tide, and also by a dock at Limehouse called the Limekiln Dock; it was 356 feet long, 55 feet wide on the floor, 53 feet at the entrance, and 20 feet of water over the sill. The outer apron was laid in Portland cement, the entrance was of brick, the sides and bottom of concrete, and the cost had been only £15,000. There were, at the present time, two vessels in that dock of the aggregate tonnage of 3,000 tons.

Mr. A. M. Reedel said, his responsibility in regard to the pontoon which was now lying at the bottom of the London Docks was not material. Rose and Crowder, who worked, for some time, the hydraulic lift at the Victoria Docks, proposed to the London Dock Company, to lease a part of the eastern dock, and to build a pontoon there on their principles. The committee referred the proposal to the pontoon, and the pontoon was constructed. He heard nothing more of the matter till he was informed, that the pontoon had gone down head foremost to the bottom of the dock. On looking into the plan of the pontoon he found that it had no bulkheads; consequently, the water, when let into it, filled one side of the parallell, and the other side, which should have been steadied, being constructed in a most inefficient manner, were torn from the ground, and the whole structure sank. The fact that the water could not be reduced by pumping led him to think that it was impossible to raise materials to a height of 60 feet, or 40 feet thickly laid in a hole in her bottom. On the general subject he would say, there could be no question that the hydraulic lifts were very useful in their actual situation; but he was not prepared to admit their applicability to all docks. For instance, at the London Docks, he apprehended that land alone would cost about £40,000 per acre. He would mention that he had completed a dry dock at Leith, 400 feet long, 84 feet wide, with 24 feet 6 inches of water on the sill, the cost of which, including caisson, engine-house, pumps, and all complete, had been £26,000. The engines worked up to 100 H.F., and were applied to a large Appold pump. So long as ordinary docks could be constructed at cost, he did not think docks of the character under discussion would be constructed in this country.

Mr. A. Giles thought many advantages would attend the application of this beautiful invention in ports such as London and Liverpool, and perhaps Hull; but, apart from those ports, he considered there were no others which could be called for. He did not think the objection which had been stated applied, because the boilers were not generally put on board while the vessel was in a dry dock; at the same time, in matters of general repair, it might be a disadvantage to have them being supplied from the level of the dock. With regard to the

* Read before the Institution of Civil Engineers.

shoring of ships on the pontoons, some merit was claimed for the absence of strain upon the ship, by the putting in of the bilge blocks. He did not know what there was to prevent the same sort of shoring being used in ordinary dry docks. The fact, however, that bilge blocks were not used seemed to be good evidence that such shores were not necessary during an engagement of twenty-five minutes, during which all sizes, up to 4,000 tons, he had never yet heard of an injury having arisen from the want of bilge blocks. The position of a vessel on bilge blocks was similar to that of a vessel on the beach, and there was great danger of the breaking of the vessel from the wind. He thought there must be some advantage in groundying upon the keel, and in putting in, when the ship touched the blocks, horizontal shores against the altars, for the purpose of keeping her upright on her keel. The proposed system of bilge blocks was quite unnecessary. Comparing the statistics supplied by the Author with those of the Southampton Docks, it appeared that at the Victoria Docks, 1,055 vessels of an aggregate tonnage of 712,880 tons had been docked by these lifts in seven years. At Southampton, during the last seven years, 493 vessels had been docked of an aggregate tonnage of 965,000 tons. The average tonnage of the vessels docked by the pontoon system was only 276 tons per ship, while the average of the vessels docked at Southampton was 99,000 tons per ship. This was a sufficient instance, if no damage had been sustained from the absence of the bilge blocks, it might be safely inferred that they were not necessary. As to the cost of docking vessels, the Author had given it at £3 per vessel, for putting on the pontoon, pumping, and lifting; if that calculation was correct, the system at the Victoria Docks had a great advantage in cost, and perhaps in respect of the cost of docking. His experience was, and he could vouch for the correctness of the figures, that the total expense of docking including pumping, labour, and repairs was, on an average, £13 per ship, and the average cost for ships of double the size was £25; and this for the use of the Thames Graving Dock Company. It was evident that there must be some other element of expense which had not been reckoned. The charges for docking ships on the patent lift were about the same as for dry vize., 6d. per foot, whereas the charge for docking at the Victoria Docks was 2s. 6d., or nearly three times the cost for the use of the pontoon. For a 1,000 ton ship, the charge for docking at Southampton was £25, and the rate for the use of the dock was in the same proportion as for the use of the pontoons. With 20,000 tons docked at the Victoria Docks, the cost of the patent lift, the Company had earned £39,000 and the expenses had been about £8,000; the average amount paid by each ship being £55, and the expenses £13. If, therefore, the charges were practically the same in both cases, and the expenses and the capital charges the same, how was it that the Company had been such a commercial failure? These figures, if correct, ought to have shown a good profit. With regard to the first cost of the hydraulic lift docks, it was stated to be £88,000; but he believed interest had been charged to capital to swell it to that amount, for this reason only, that it was beyond the ordinary limits of the rules of the dock company. Under discussion, the sum of £28,000 gave a capability of docking seven ships at a time, he confessed, that, by the ordinary system, with the same number of docks, it could not be done at the same price. He thought he had shown why a saving in respect of the equipment of pithy power, coffer-dams, pumping-power, caissons, and everything complete, was £88,000. One of the 200 foot long, with a 64 feet caisson, and 24 feet of water over the sill. The other was 300 feet long, 45 feet opening, and 21 feet of water over the sill. He was asked to design a system of docks, one of which should accommodate vessels of 6,000 tons, or 7,000 tons, and the other of smaller sizes, and he believed he was able to design docks for £150,000; but if the hydraulic lift and seven pontoons, one of which should be capable of carrying the 'Warrior,' could be constructed for £88,000, that system would surpass any other he knew of in point of economy. A system of eight or nine docks, each of 150 feet of six docks of various sizes (the largest of which was capable of docking the 'Warrior'), including six acres of land, with pumps and every necessary appliance, could be completed for £165,000.

As to the capability of docks with hydraulic lifts compared with ordinary docks, the time occupied in lifting a ship had been given as twenty-five minutes. That could not, however, be meant to include the whole operation of putting a ship on the pontoon, lifting, and moving her into her berth; for he understood that, practically, the time was occupied in preparing the bilge blocks, floating the bilge blocks, floating her into position, sinking the pontoon, lifting the ship, and getting her into berth, occupied about four and a half hours; whilst the operation of unloading occupied about one hour and a half. If that were so, the capability of work on one lift (though there might be fourteen pontoons or fifteen pontoons), was limited, by
the ordinary system, one ship could be docked at each tide; but in the large dock at Southampton, which had been constructed twelve years, more had been accomplished. Upon one occasion, three large ships, each of more than 2,000 tons, required to be docked in a hurry; two were docked and undocked, and the third was docked and placed on the blocks between daylight and dark. He thought he believed the capability of that dock was almost as great as that of one lift.

Mr. John Heppel said, having had the advantage of being associated in the preparation of the plans for this work, a few words from him might not be amiss. He necessary to say the same thing as had been said about all the mechanical details of the construction, and the considerations which led to the adoption of them. To this part of the question he proposed strictly to confine himself, leaving the commercial and general aspects of the question to those who were familiar with the present apparatus. He did not mean to say that the proposal was not a good one; but he thought, it must be obvious that dragging a vessel about upon cradles must expose it to greater strains and abrasions than those with which it was in the hydraulic lift. However, it might be said, with regard to such a lifting dock, it would be easy to use it in connection with pontoons, in the same way as the hydraulic lift; and in that case the Author of the Paper would be entitled to the credit of the invention beyond all danger; but even then it would be inferior. He spoke under correction; but he hardly imagined, that a floating dock of that kind, having equal lifting power with the hydraulic press at the Victoria Docks, could weigh less than 2,000 tons. If his conception of the invention beyond all danger: for every vessel, large or small, lifted with that apparatus, a deal weight of 2,000 tons was being lifted with it, instead of less than 700 tons at a maximum, which was capable of reduction in proportion to the load to be raised. He therefore thought the floating dock, even in the best forms of the Victoria Docks, a model of economy and efficiency of power, to that which was now the subject of discussion.

There was one other point. It was admitted, that for a fixed water-level, the Hydraulic Lift was not an inconvenient apparatus; but it could not be employed, without repairs, for floating docks. If this was found to be the case, and his only wish was to draw attention to the fact, that in this case, there was a free choice between the Victoria Docks and the tideways of the Thames, and it was considered, on all accounts, more desirable to employ the Victoria Docks, however distressing its situation, with the latter, the greater facility of communication with the dock being considered of more value than the mechanical power derived from the tide, and he thought, that similar considerations would prevail in most cases of a similar character. He had seen a small apparatus, and he was struck with the remarkably good condition in which it was kept. Every part was in good working order, and in charge of highly intelligent people. He thought the mechanical results had been such as to place the proposal beside the ordinary, and the commercial results that would follow would be such as to remunerate those individuals who had ventured to try, what was considered at the time, a very bold experiment.

Mr. E. Readman, said, it must be acknowledged, that the thanks of the Government committee were due to the Author for this attempt to facilitate the raising of vessels in the port of London. Some years ago he placed a Paper before the Institution on the variety in direction of the different Metropolitan dry docks, and he was bound to say that the want in this respect, he thought, was still greatly exemplified in the mode of construction of the various docks upon the Thames. Whether the Thames—a tidal river, which had hitherto done what was now attempted by means of this most ingenious apparatus—was the best site, remained to be proved by experience. Undoubtedly, a gravy dock, at the end of the Victoria Docks, might have been drained by the action of the tide, and the dock might have been arranged as others had been on the Thames. Certainly the element of cost was one of the greatest importance: but it could not be thinking a comparison of the cost of the use of this system was to be confined to cases of fixed, or nearly fixed water-level, there would still be the Baltic, the Mediterranean, and nearly all the ports on the Pacific; and he thought, perhaps, the Author would be the last to blame for that apparatus, and he was struck with the remarkably good condition in which it was kept. Every part was in good working order, and in charge of highly intelligent people. He thought the mechanical results had been such as to place the proposal beside the ordinary, and the commercial results that would follow would be such as to remunerate those individuals who had ventured to try, what was considered at the time, a very bold experiment.
The section of the dock was parallel to that of the ‘Trafalgar,’ a 120 gun-ship, and of course the work was carried out in the most costly manner. The early timber docks of London included the old Pitcher’s Dock at Blackwall, which was subsequently rebuilt by the present owners (Mr. Soames); were built entirely of timber and of clay paddle. The beams of wood, the shipbuilding piles, the number of piles being placed in the direction of the line of the keel. The old Pitcher’s Dock had failed in a similar way to that at Woolwich, from the hydrostatic pressure. Another reason why the comparison of cost was of great interest was that, with the exception of a very few exceptions, were dry docks in two sizes of the world; they were not only dry when the gates were shut and the vessel was docked, but any amount of leackage which accumulated in the dock was drawn away by the tide. The least deviation, in a cost of £90,000 to £90,000. Another class, capable of admitting men-of-war, had amounted to £100,000 and upwards.

But in general a good graving dock of ordinary construction might be said to cost from £15,000 to £20,000, capable of admitting all ordinary vessels, and two at a time of the smaller class; and when once properly constructed they wanted no repairs, and therefore might be called permanent structures. They thought they might well be compared with floating pontoons, admitted separately into one entrance or receptacle, having a general horizontal position, instead of the pontoons supporting the vessel of order, and requiring much manipulation, which he considered a more costly affair than a substantial graving dock of the ordinary form.

Mr. G. B. Rennie said, in reference to a model, which he had placed on the table, that it represented the works constructed at Greenwich and Woolwich. The vessels were to be transported by the floating dock, of hauling them ashore by hydraulic pressure, or on cradles. The ways were perfectly level, and the amount of power required to haul them on shore might be calculated on the consideration, that the launch-ways were 5 fathoms with a weight of 25,000 tons, and where there were four lines of horizontal ways, which were used for hauling the vessels on shore. He believed the largest vessel operated upon by this system, was the ‘Kaiser,’ a screw line-of-battle ship of 84 guns. The floating-dock at Fola was wood fixed.

With regard to the Hydraulic Lift Graving Dock, he had several times seen vessels lifted, and it seemed to be done with great ease, regularity, and apparent safety. He did not agree with the Author as regarded the capability of a vessel landing on the shelf of a graving dock. He believed there must be a strain on the vessel; and it was always desirable to prevent undue strain, as far as possible. However strong a ship might be, there must be some extra strain if it had to support the piers. The Author (Mr. Conan) had said, that the bottom of the vessel, consisting of a series of cylinders and piers, precisely similar in principle to the Bramsh Prose, and connected by vertical chains to the ends of the transverse beams, underneath the pontoon gridiron. When the enormous increase of the dock of the port of London was considered, and the efforts which had been made to develop the commerce, the thanks of the commercial community were due to the Author. He had, however, one advantage which no other engineer, acting for a public body, had, the Victoria Dock was constructed by the Author for the Company that obtained powers to construct brick docks. The old Wapping Dock Act contained clauses for graving docks, but the shipbuilding interest was too powerful in that day, and those clauses were struck out in every Dock Act afterwards. Whether a dock Company could build and operate with the same expense as private docks was another question; but he felt convinced, from the experience of some years, that that exclusive principle, together with the tyranny of trade unions amongst shipwrights, had, to a great extent, driven the old ship-building trade from the port of London. The late Mr. Duncan Dunbar had frequently told him, that on the Tyne and other ports, he could get his ships built, with lower masts and standing rigging, at the same price as that which he paid for the hull alone, in the port of London.

Mr. John Murray remarked, that in the discussion which had taken place, they considered they had not arrived at the full cost of this pontoon dock. Mr. Clark had given the expense of the excavations, the coffer-dams, etc., but the enormous area occupied by the works—some 56 acres in extent, 16 of which were water, and ought to be added to the sum of £68,000. A comparison between this pontoon dock and ordinary dry docks of masonry or brickwork might form a subject of discussion. He had ascertained the cost of graving docks in various parts of the country, which, combined with the information already given, might prove useful. Mr. Abernethy had stated that the average cost of the seven docks at Birkenhead and the two at Liverpool was £14,000; whereas the cost of the two at £28,000; that at Belfast, in 1840, £19,362; and the dock built by himself at Sunderland, including pumps, engine, and enclosure, cost £13,185. On taking an average of the four docks, it amounted to £18,980. Those docks were 600 feet long, 200 feet wide, and 20 feet deep, and 70 feet across the coping, and 36 feet at the bottom, and they were each capable of admitting two ordinary vessels, or one large ship. The dock of Sunderland had a platform on the side, with a temporary end, so that it might be lengthened when required. Docks of this kind had been constructed, therefore, at an average cost of £18,000 to £20,000 each. They were all of good masonry and substantial workmanship. But in the port of Sunderland and on the River Tyne docks of a lighter description had been constructed, capable of holding one ship at a time, and at a cost of from £3,000 to £6,000. Berlin had several of the shipbuilding yards, in which vessels were brought for repairs. One of the earliest of these docks was an old gun-brig ship cut down for the purpose. The deck and upper works being taken away, moveable graving docks were placed, and she had a traverse in a floating dock. The shipbuilders had since constructed other floating docks in the ordinary manner. Docks of a better description, such as those at Liverpool, lined with granite and of a large size, had been commenced at a cost of from £5,000 to £6,000. Another class, capable of admitting men-of-war, had amounted to £100,000 and upwards.

The second drawing represented an ordinary stone dock (that referred to by the Author in his Paper), showing half midship sections of the ‘Bellerophon’ and the ‘Lord Nelson.’ The third represented the side view of a ship, with gauge-marks parallel with the original straight line of keel, for ascertaining precisely the hogging or cambering of the vessel.
than 1,000 tons; vessels of less than that tonnage might be safely docked as at present. The breast-shores being carefully fixed (the keel being only just clear of the blocks), the dock should be lifted sufficiently for the keel to bear on all the blocks; in this position some of the blocks might be drawn under the bilge, but the keel would require them; for small vessels this operation at that time was not necessary. The pontoon might then be lifted, until the keel-blocks were out of the water, and the vessel might, then, be as completely abore, as in the case of sailing vessels, and such heights might be assumed as appear to be required. The vessel being completely secured on the pontoon, the breast-shores would be removed, and the vessel might be safely floated away from the dock on the pontoon to a shallow dock, as at the Yarmouth Docks, or to a wharf, or basin; or for executing extensive repairs, the pontoon might be grounded on a 'gridiron' at a basin wharf.

The docking duties in times of war, for Her Majesty's naval establishments, might be classed under three divisions:

1. During the actual commencement of hostilities.
2. During a season.
3. After an action.

As regarded the preparations, probably every available vessel, capable of being drawn under the bilge of the pontoon, might be missioned for the service; those already commissioned as well as those taken from the merchant service—out of 'ordinary,' as it was called—might require to be docked; until a vessel was in dock, the time that she occupied would be a diminution of other work, and when usefully docking duties, he considered the Hydraulic Lift Dock, with its ten pontoons, or fifteen pontoons, might prove an inconsiderable advantage, being equal to as many additional docks.

He would particularly stress that, for the great naval establishments, particularly in time of war, when all the duties of those establishments had to be carried on with the greatest dispatch, and with uncertain accuracy, under great pressure. It might probably not be prudential to attempt docking vessels by the system to the extent of from 10,000 to 15,000 tons, as proposed by the Author of the Paper some years ago, yet it was desirable that the Institution should give an opinion as to that proposition being carried into practice for vessels up to a certain class of ships, that vessels might be docked in a sea-going state, might safely be docked by the method proposed.

The system of shutting he had described was equally applicable to every form of graving dock. He had submitted the drawing of the two half-sections, to show that the 'hoggins' did not require the bilge-blocks, but that the 'Lord-Warden' was necessary to them to a certain extent. That form of support was the best in his experience, and it might be applied to the Hydraulic Lift Dock. It was a matter of great national importance, to determine whether the Author's method of docking ships for repair, with the greatest accuracy, might not be carried into effect. As the limit of the tonnage which he had suggested (4,000 tons) it should be borne in mind, that his suggestions had reference only to the war establishments of the navy; that vessels of the class proposed by him would not cause inconvenience in management; that to one vessel even of such tonnage, many below of smaller tonnage would have to be employed, and might have to be repaired; that the pontoons would not be unreasonable expensive, or occupy unreasonable space; that, for an establishment such as that at Portsmouth, it was the practice in which the vessel would be docked, to other basins less occupied; and it would not be necessary for the kind proposed to be adopted, the ordinary docks might not be wanted for small vessels, but would be generally available for such ships of the line as would be required to join the fleet with the utmost dispatch. With the same arguments, he might express doubts on the propriety of the Author's plan, which might be more easily docked in a dock of this nature and the depth of a pontoon which carried the vessel in the lifting dock system. The depth of the sides of the floating dock was 40 feet, while in the Victoria dock the depth of the pontoon was only 6 feet, and 4 feet, 6 feet and 6 feet, as an approximate guide, viz., that the deflection of each girder was as the square of its depth, there would be such an enormous difference in rigidity as to make it evident that the Author had widely departed from the principles of the present system, and to destroy the necessary flexibility, instead of perfect rigidity. The first point to consider was, which of the two systems was most adapted for a vessel which was taken out of the water. There was no doubt that any system which would enable the vessel to assume perfectly the same position when out of water as she assumed when in the water, would be the most perfect system; but that was a difficult thing to attain in practice, and it was much to be
doubted whether the system of flexibility in a pontoon would effect it: and it was difficult to say beforehand, what form the keel of a vessel would assume, if put upon a flexible platform. It had been said, that the line of the keel could be adjusted, by managing the pontoon properly, and that if the keel took a different shape from that which it had when the vessel was in water, it could be corrected and rectified by letting in water in the different compartments of the pontoon. Now that appeared to be a delicate operation, and if through carelessness, or any other cause, the water happened to be let in the wrong compartment there might be serious results. On the other hand, with the system of a sandy rigid dock bottom, the vessel would probably not be got perfectly into the same position in which she was when in the water; but an average result would be obtained, by bringing the keels of all vessels to a description of dock, it could not be ascertained whether a vessel would move to such an extent as to be injurious, unless the ship were a very cranky one indeed; for that reason rigidity in the dock bottom was preferable, in practice, to the system of flexibility.

There was another point which occurred to him, namely, that if a pontoon were sunk to the bottom of a dock independently of the hydraulic apparatus, then, when the water was simply pumped out of it, the vessel could be raised by the pontoon alone, without the intervention of the hydraulic lift; and thus it would be possible to raise the whole depth of the dock, as the space in the bottom of the lifting-dock, which was occupied by the cross girders, would not then be required. It seemed, at first sight, that it would be practicable to work a series of pontoons together in the same way, so as to dispense with a simple system; but he had no doubt, there were corresponding advantages which induced the adoption of the double system of lift and pontoons, and he mentioned the subject, in order to see if any new views were induced upon it.

It had been said, rather, in the way of objection to the system at the Victoria Docks, that it was commercially unsuccessful until the repairing shops were established. It seemed to him, with regard to such docks, there was an amount of accommodation from the grading docks, that if the Company did not afford the shipping public every possible convenience, they could hardly expect to get the amount of trade, which would be secured by rival establishments, and it was hoped for a dock in London without that accommodation for repairs, with a dock at Southampton, which was exposed to no opposition or rivalry, and which without a repairing establishment, might make a fair return on its capital; while a similar dock in London, where there was a great deal of opposition, would get little business.

Mr. G. H. Phillips said, it must be clear to all, that before approving of the description of dock, it could not be ascertained whether a vessel would move to such an extent as to be injurious, unless the ship were a very cranky one indeed; for that reason rigidity in the dock bottom was preferable, in practice, to the system of flexibility.

Mr. R. R. Grove, F.R.S., President, British Association for the Advancement of Science, 1866-7. (Concluded from page 252.)

I may perhaps be permitted to recall a forgotten experiment, which nearly a quarter of a century ago I showed at the London Institution, an experiment simple enough in itself, but which then seemed to me important from the consequences to be deduced from it, and the importance of which will be much better appreciated now than it was then.

A trick of multiplying wheels ended with a small metallic wheel which, when the train was put in motion, revolved with extreme rapidity against the periphery of the next wheel, a wooden one. In the metallic wheel was placed a small piece of phosphorus, and as long as the wheels revolved, the phosphorus remained unaltered, but the moment the last wheel was stopped by moving a small lever attached to it, the phosphorus burst into flame. My object was to show that while motion of the mass continued, heat was not generated, but that when this was arrested, the force continuing to operate, the motion of the mass became heat in the particles. The experiment differed from that of Humphry Davy's cannon-boring and Davy's friction of ice in showing that there was no heat while the motion was unresisted, but that the heat was in some way dependent on the motion being impeded or arrested. We have now become so accustomed to this view, that whenever we find motion resisted we look to heat, electricity, or some other force as the necessary and independent result.

It would be out of place here, and treating of matters too familiar to the bulk of my audience, to trace how, by the labours of Oersted, Seebeck, Faraday, Talbot, Daquerre, and others, the way has been prepared for the generalization now known as the correlation of forces or conservation of energy, which includes, as a special case, the law of the conservation of energy, as discovered by Thomson, and others (among whom I would not name myself), it was not that I may be misunderstood and supposed to have abandoned all claim to a share in the initiation of this, as I believe, important generalization, have carried on the work, and how, sometimes by independent and, as is commonly the case, nearly simultaneous deductions, sometimes by progressive and accumulated discoveries, the doctrine of the reciprocal interaction of the quantitative relation, and of the necessary dependence of all the forces, I think I may venture to say, been established.

If magnetism, be, as it is proved to be, connected with the other forces of nature, if in other words, if the forces of nature always produce, as they are proved to do, lines of magnetic force, at right angles to their lines of action, magnetism must be cosmical, for where there is heat and light, there is electricity and consequentially the magnetic. Magnetism, then, must be cosmical and not merely terrestrial. Could we trace magnetism in other planets and stars as a force which is not only true in lines, i.e., in lines cutting at right angles the curves formed by their rotation round an axis, it would be a great step; but it is one hitherto unaccomplished. The apparent coincidences between the maxima and minima of solar spots, and the decennial or sub-decadal periods of terrestrial magnetic intensity, though only empirical at present, might tend to lead us to a knowledge of the connexion we are seeking; and the President of the Royal Society considers that an additional epoch of coincidence has arrived, making the fourth decennial period; but some doubt is

* Inaugural Address delivered at the Annual Meeting of the British Association, Nottingham, August, 1869.
thrown upon these coincidences by the magnetic observations made at the Greenwich Observatory. In a paper published in the "Transactions of the Royal Society," 1863, the Astronomer Royalsays, speaking of results extending over seventeen years, there is no appearance of decennial cycle in the recurrence of great magnetic disturbances, and Mr. Glaisher last year, in the physical section of this Association, stated that after persevering examination he had been unable to trace any connexion between the magnetism of the earth and the spots on the sun.

Mr. Airy, however, in a more recent paper suggests that currents of magnetic force having reference to the solar hour are produced from the surface of the sun to the orbit of the earth, and he invites further co-operative observation on the subject, one of the highest interest, but at present remaining in great obscurity.

One of the most startling suggestions as to the consequences resulting from the dynamical theory of heat is that made by Mayer, that by the loss of heat occasioned by friction of the tidal waves, as well by their forming, as it were, a drag upon the earth's rotary movement, the velocity of the earth's rotation must be gradually diminishing, and that thus, unless some undiscovered compensatory action exist, this rotation must ultimately cease, and changes hardly calculable take place in the relative position of the heavenly bodies.

M. Delaunay considers that part of the acceleration of the moon's mean motion which is not at present accounted for by planetary disturbances, to be due to the gradual retardation of the earth's rotation; to which view, after an elaborate investigation, the Astronomer Royal has given his assent.

Another most interesting speculation of Mayer is that with which you are familiar, viz., that the heat of the sun is occasioned by friction or percussion of meteorites falling upon it: there are some difficulties, not perhaps insuperable, in this theory. Supposing such comical bodies to exist in sufficient numbers, the moon might revolve round the sun, fall into it, not as an aerolite falls upon the earth directly by an intersection of orbits, but by the gradual reduction in size of the orbits, occasioned by a resisting medium; some portion of force would be lost, and heat generated in space by friction against such medium; when they arrive at the sun they would, assuming them to be large, revolve in the direction of the sun's rotation; all impinging in a definite direction, and we might expect to see some symptoms of such in the sun's photosphere; but though this is in a constant state of motion, and the direction of these movements has been carefully investigated by Mr. Carrington and others, no such general direction is detected; and Mrs. Saye, who is writing a paper on this subject, says Mayer gives no adequate reason for his belief that the velocity of the moon, as measured by the longitudes of the planets, is caused by frictional resistances.

It might be expected that comets, bodies so light and so easily deflected from their course, would show some symptoms of being acted on by gravitation, were such a number of bodies to exist in or near their paths as are presupposed in the mechanical theory of solar heat.

Assuming the undulatory theory of light to be true, and that the motion which constitutes light is transmitted across the interplanetary spaces by a highly elastic ether, then, unless this motion is confined to one direction, unless there be no interference, unless there be no viscosity, as it is now termed, in the medium, there is no friction, light must only lose something in its progress from distant luminous bodies, that is to say, must lose something as light; for, as all reflecting minds are now convinced that force cannot be annihilated, the force is not lost, but its mode of action is changed. If light, then, is lost as light (and the observations of Struve seem to show this to be so), there may be no constant that it is far less than has been in consequence of its luminous emissions becoming extinct), what becomes of the transmitted force lost as light, but existing in some other form? So with heat: our sun, our earth, and planets are constantly radiating heat into space, so in all probability are the other suns, the stars, and their attendant planets; it becomes of the heat thus radiated into space? If the universe have no limit, and it is difficult to conceive one, there is a constant evolution of heat and light; and yet more is given off than is received by each cosmic body, for otherwise night would be as light and as warm as day. What becomes of the enormous force thus apparently non-recurrent in the same form? Does it return as palpable motion? Does it move or contribute to move suns and planets? and can it be conceived as a force similar to that which Newton speculated on as universally repulsive and capable of being substituted for universal attraction? We are in no position to answer such questions as these; but I know of no problem in celestial dynamics more deeply interesting than this, and we may be no further removed from its solution than the predecessors of Newton were from the mathematical solution of the problems of the motion of the planets, with which which that potent intellect detected and demonstrated.

Passing from extra terrestrial theories to the narrower field of molecular physics, we find the doctrine of correlation of forces steadily making its way. In the Bakerian Lecture for 1863 Mr. Sorby shows, not perhaps a direct correlation of mechanical and chemical forces, but that when, either by solution or by chemical action, a change in volume of the resulting substance as compared with that of its separate constituents is effected, the action of pressure retards or promotes the change, according as the substance formed would occupy a larger or a smaller space than that occupied by its separate constituents; the application of these experiments to the explanation of subterranean changes which may have taken place under great pressure, is obvious, and we may expect to form compounds under artificial compression which cannot be found under normal pressure.

In a practical point of view the power of converting one mode of force into another is of the highest importance, and with reference to a subject which at present, somewhat prematurely, perhaps, occupies men's minds, viz., the prospective exhaustion of our coal-fields, there is every encouragement derivable from the knowledge that we can at will produce heat by the expenditure of other dynamos; far more than that, we may probably be enabled to absorb or store up as it were diffused energy—force, for instance, Berzelius has found that the potential energy of formate of potash is much greater than that of its proximate constituents, caustic potash and carbonic oxide. This change may take place spontaneously and at ordinary temperatures, and is by such change that we may be enabled to re-invest with the amount of potential energy which its carbon possessed before uniting with oxygen; or, in other words, the carbonic oxide is raised as a force-possessor to the place of carbon by the direct absorption or conversion of heat from surrounding matter.

We have as to force-absorption, an analogous result to that of the formation of coal from carbonic acid and water; and though this is a mere illustration, and may never become economical on a large scale, still it and similar examples may calm apprehension as to future means of supplying heat, should our present fuel become exhausted. As the sun's force, spent in times long past, is now returned to us, which was formed by that light and heat, so the sun's rays, which are daily wasted, as far as we are concerned, on the sandy deserts of Africa, may hereafter, by chemical or mechanical means, be made to light and warm the habitations of the denizens of colder regions. The tidal wave is, again, a large reservoir of force hitherto almost unused.

The valuable researches of Prof. Tyndall on radiant heat afford many instances of the power of localizing, if the term be permitted, heat which would otherwise be dissipated.

The discoveries of Graham, by which atmospheric air, drawn through films of caoutchouc, leaves behind half its nitrogen, or, in other words, becomes lighter by half in oxygen, and hence has a much increased potential energy, not only shows a most remarkable instance of physical molecular action, merging into chemical, but afford us indications of means of storing up force, much of the force used in working the aspirators capable at any period, however remote, of being evolved by burning the oxygen with a combustible material.

What changes may take place in our modes of applying force before the coal-fields are exhausted it is impossible to predict. Even guesses at the probable period of their exhaustion are uncertain. There is a tendency to substitute for smelting in metallurgy, processes, liquid chemical in action, whose course has the effect of saving fuel; and the waste of fuel in ordinary operations is enormous, and can be much economized by already
known processes. It is true that we are, at present, far from seeing a practical mode of replacing that granary of force the coal-fields; but we may with confidence rely on invention being in this case, as in others, born of necessity, when the necessity arises.

I will not further pursue this subject; at a time when science and civilization cannot prevent large tracts of country being irrigated by human blood in ordinary to gratify the ambition of a few restless men, it seems an over-refined sensibility to occupy ourselves with providing means for our descendants in the tenth generation to warm their dwellings or propel their locomotives.

Two very remarkable applications of the convertibility of force have been recently attained by the experiments of Mr. Wilde and Mr. Holtz; the former finds that, by conveying electricity from the coils of a magneto-electric machine to an electro-magnet, a considerable increase of electrical power may be attained, and by applying this as a magneto-electric machine to a second, and in turn to a third electro-magnetic apparatus, the force is largely augmented. Of course, to produce this increase, more mechanical force must be used at each step to work the magneto-electric machines; but provided this be supplied there hardly any limit to the extent to which mechanical may be converted into electrical force.

Mr. Holtz has contrived a Franklinie electrical machine, in which a similar principle is manifested. A varnished glass plate is made to revolve in close proximity to another plate having numerous pieces of card attached, which are electrified by a bit of rubbed silk. When the current is stopped a resistance is felt by the operator who turns the handle of the machine, and the slight temporary electrization of the card converts into a continuous flood of intense electricity the force supplied by the arm of the operator.

These results offer great promise for extended application; they show that, by a more formal disposition of matter, one force can be converted into another, and that not to the limited extent hitherto attained, but to an extent co-ordinate, or nearly so, with the increased initial force, so that, by a mere change in the arrangement of apparatus, a means of absorbing and again eliminating a force, a given force may be obtained to an indefinite extent. As we may, in a not very distant future, need, for the daily uses of mankind, heat, light, and mechanical force, and find our present resources exhausted, the more we can invent new modes of conversion of forces, the more prospect we have of practically supplying such want. It is but a month from the time that to the greatest triumph of science-creation has been attained. The chemical action generated by a little salt water on a few pieces of zinc will now enable us to converse with inhabitants of the opposite hemisphere of this planet, the Atlantic Telegraph is an accomplished fact.

The facts made known to us by geological inquiries, while on the one hand they afford striking evidence of continuity, on the other, by the breaks in the record, may be used as arguments against it. The great question once was, whether these chasms represent sudden changes in the formation of the earth's crust, or whether they arise from dislocations occasioned since the original deposits of strata or from gradual shifting of the areas of submergence. Few geologists of the present day would, I imagine, not adopt the latter alternative. Then comes a second question, whether, when the geological formation of a continuous character, the different characters of the fossils themselves, or permanent varieties, or may be explained by gradual modifying causes.

Prof. Ansted, summing up the evidence on this head as applied to one division of stratified rocks, writes as follows:—

"Palaontologists have endeavoured to separate the Lias into a number of subdivisions, by the Ammonites, groups of species of those long characteristic of different zones. The evidence on this point rests upon the assumption of specific differences being indicated by permanent modifications of the structure of the shell. But it is quite possible that these may mean nothing more than would be due to some change in the conditions of existence. Except between the Marlstone and the Upper Lias there is really no Palaontological break, in the proper sense of the words; alternations of form and size consequent on the occurrence of circumstances more or less favourable, migration of species, and other well-known causes, sufficiently account for many of those modifications of the form of the shell that have been taken as specific marks. This view is strengthened by the fact that other shells and other organisms generally show no proof of a break of any importance except at the point already alluded to." Therefore, irrespective of another deficiency in the geological record, which will be noticed presently, the physical breaks in the stratification make it next to impossible to fairly trace the order of succession of organisms by the evidence afforded by their fossil remains. Thus there are nine great breaks in the Palaeozoic series, four in the Secondary, and one in the Tertiary, geological time between Palaeozoic and Secondary, and Secondary and Tertiary respectively. Thus in England there are sixteen important breaks in the succession of strata, together with a number of less important interruptions. But although these breaks exist, we find pervading the works of many geologists a belief, resulting from the evidence presented to their minds, sometimes avowed, sometimes unconsciously implied, that the succession of species bears some definite relation to the succession of strata. Thus Professor Ramsay says that "in cases of superposition of fossiliferous strata, in proportion as the species are more or less continuous, that is to say, as the break in the succession of life is partial or complete, so was the time that proportionately to the close of the era and the commencement of the upper strata a shorter or a longer interval. The break in life may be indicated not only by a difference in species, but yet more importantly by the absence of older and appearance of newer allied or unaltered genera."

The connection between cosmical studies and geological researches are dawning on us: there is, for instance, some reason to believe that we can trace many geological phenomena to our varying rotation round the sun; thus, more than thirty years ago Sir J. Herschel proposed an explanation of the changes of climate on the earth's surface as evidenced by geological phenomena, founded on the changes of eccentricity in the earth's orbit.

He said he had entered on the subject "impressed with the magnificence of that view of geological revolutions which regards them rather as regular and necessary efforts of great and general causes, than as resulting from a series of convulsions and eliminations regulated by no laws and reducible to no fixed principles."

As the mean distance of the earth from the sun is nearly invariable, it would seem at first sight that the mean annual supply of light and heat received by the earth would also be invariable; but according to his calculations it is inversely proportional to the earth's orbit; so that the heat given by the sun and the eccentricity of the earth's orbit is approaching towards or at its minimum. Mr. Croll has recently shown reason to believe that the climate, at all events in the circum-polar and temperate zones of the earth, would depend on whether the winter of a given region occurred when the earth at its period of greatest eccentricity was in the northern or southern hemispheres or when it was at aphelion or perihelion. His reason may be briefly stated thus: assuming the mean annual heat to be the same, whatever the eccentricity of orbit, yet if the extremes of heat and cold in winter and summer be greater, a colder climate will result, for there will be less temperature difference. Again, the cold winter than the hot summer can melt, a result produced by the vapour (aided by the shelter from the sun's rays) suspended in consequence of the aqueous evaporation; hence we should get glacial periods, when the orbit of the earth is at its greatest eccentricity, at those parts of the earth's surface which is in aphelion during those long periods or hot periods where it is winter in perihelion; and normal or temperate periods when the eccentricity of orbits is at a minimum; all these would gradually slide into each other, and a period would be of long distant periods alternations of cold and heat, several of which we actually observe in geological records. If this theory be borne out, we should approximate to a test of the time which has elapsed between different geological epochs. Mr. Croll's computation of this would make it certainly not less than 1,000,000 years since the last glacial epoch, a time not very long in geological chronology—probably it is much more.
When we compare with the old theories of the earth, by which the apparent changes on its surface were accounted for by convulsions and cataclysms, the modern view inaugurated by Lyell, your former President, has not wholly, at all events to a great extent adopted, it seems strange that the referring past changes to similar causes to those which are now in operation should have remained uninvestigated until the present century; but with this, as with other branches of knowledge, the most simple is frequently the latest view which occurs to the mind. It is much more easy to invent a Deus ex machina than to trace out the influence of slow continuous change; the love of the marvellous is so much more attractive than the patient investigation of truth, that we find it has prevailed almost universally in the early stages of science.

In astronomy we had crystal spheres, cycles, and epicycles; in chemistry the philosopher's stone, the elixir vitae, the archaile, or stomach demon, and phlogiston; in electricity the notion that amber possessed a soul, and that a mysterious fluid could knock down a steeple. In geology a deluge or a volcano was supplied. In Paleontology a new race was created whenever theory required it; how such new races began, the theorists did not stop to inquire.

The records of life on the globe may have been destroyed by the fusion of the rocks, which would otherwise have preserved them, or by crystallization after hydrothermal action. The earth may have existed for millions of years in a state of nonexistence, or the heat of the sun may have been so increased as to destroy all organic life. How the species came into existence, or whether all the species now living are descendants of one from which all the others were derived, we cannot restore. We are left to the descent of the species, or we are left to the survival of the fittest.

For the present, the only alternative is to proceed on the supposition that the number of species has been limited, and that they have been maintained in the same condition through one hundred million years, and that the one hundred million people in Europe, it follows, that a great number of the ancestors of the present people must have intermarried with relations, and then the pedigree, going back to the time of the Conquest, instead of being represented by diverging lines, would form a network so tangled that no skill could unravel it; the law of probabilities would make it impossible for any two people in the same country, taken at hazard, would not have any generations to go back before they would find a common ancestor, who probably, could they have seen him or her in the life, had no traceable resemblance to either of them. Thus two animals of a very different form, and of what would be termed very different species, may have several common ancestors, yet the skill of no comparative anatomist could trace the descent.

From the long continued conventional habit of tracing pedigrees through the male ancestor, we forget in talking of progenitors that each individual has a mother as well as a father, and there is no reason to suppose that he has in him less of the blood of the one than of the other.

The recent discoveries in Paleontology show us that man existed on this planet at an epoch far anterior to that commonly assigned to him. The instruments connected with human remains, and indisputably the work of human hands, show that to these remote periods the term civilisation could hardly be applied—certainly the rude tools of the savages of Central America may have been made by the same hand that fashioned the implements of the flint anvil, or the polished flint in the hand and chipping off portions of it by striking it against a larger stone or rock; then, as time suggested improvements, it would be more carefully shaped, and another stone used as a tool; then (at what intervals we can hardly guess) it would be ground, then roughly polished, and so on—subsequently bronze weapons, and, nearly the last before we come to historical periods, iron. Such an apparently simple invention as a wheel must, in all probability, have been far subsequent to the rude hunting tools or weapons of war to which I have alluded.

There is nothing, as Prof. Huxley has remarked, like an extinct order of birds or mammals, only a few isolated instances. It may be said the ancient world possessed a larger proportion of fish and amphibians, and was more suited to their existence. I see no reason for believing this, at least to anything like the extent Prof. Huxley imagines. It is not more easy to invent a course of being preserved for future ages would give the same idea to our successors.

Crowded as Europe is with cattle, birds, insects, &c., how few are geologically preserved! while the muddy or sandy margins of the ocean, the estuaries, and deltas are yearly accumulating unnumbered tons of the bodies of sea animals and reptiles and for the study of future Paleontologists.

If this position be right, then, notwithstanding the immense number of preserved fossils, there must have lived an immeasurably larger number of unpreserved organic beings, so that the chance of filling up the missing links, except in occasional instances is very slight. Yet where circumstances have remained suitable for their preservation, many closely connected species are preserved—in other words, while the intermediate types; and in these cases the oppositions of continuity lay all stress on the lost and none on the existing links.

But there is another difficulty in the way of tracing a given organism to its parent form, which, from our conventional mode of tracing genealogies, is never looked upon its proper light. It is a very different matter to ask for the parent type of a given form? Each of us, supposing none of our progenitors to have intermarried with relatives, would have had at or about the period of the Norman Conquest upwards of a hundred million direct ancestors of that generation, and if we add the intermediate ancestors double that number. As each individual has a male and female parent, we have to multiply by two for each thirty years, the average duration of a generation, and it will give the above result.

Let any one assume that one of his ancestors at the time of the Norman Conquest was a Moor, another a Celt, and a third a Laplander, and that these three were preserved; then all the others were lost, he would never recover one of them as his ancestor, he would only have the one-hundred millionth of the blood of each of them, and as far as they were concerned there would be no perceptible sign of identity of race.

But the problem is more complex than that which I have stated, that there may have existed at any time a hundred million people in Europe, it follows, that a great number of the ancestors of the ancestors of the present people must be the same, and then the pedigrees, going back to the time of the Normans, instead of being represented by diverging lines, would form a network so tangled that no skill could unravel it; the law of probabilities would make it impossible for any two people in the same country, taken at hazard, not have any generations to go back before they would find a common ancestor, who probably, could they have seen him or her in the life, had no traceable resemblance to either of them. Thus two animals of a very different form, and of what would be termed very different species, may have several common ancestors, yet the skill of no comparative anatomist could trace the descent.

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the works of Darwin, Hooker, Huxley, Carpenter, Lyell, and others must be examined. If I appear to lean to the view that the successive changes in organic beings do not take place by sudden leaps, it is, I believe, from no want of an impartial feeling; but if the facts are stronger in favour of one theory than another, a more audacious attempt of impartiality to make the balance appear equipoised.

The prejudices of education and associations with the past are against this as against all new views; and while on the one hand a theory is not to be accepted because it is new and primeval fancy, on the other, I need not say that its running counter to existing opinions is a sure indication for its rejection; the *cursus probandi* should rest on those who advance a new view, but the degree of proof must differ with the nature of the subject. The fair question is, Does the newly proposed view remove more difficulties, require fewer assumptions, and present more consistency with observed facts than that which it seeks to supersede? If so, the philosopher will adopt it, and the world will follow the philosopher—after many days. It must be borne in mind that even if we are satisfied from a persevering and impartial inquiry that organic forms have varied indefinitely in time, the *cursus causae* of these changes is not explained by our researches; if it be admitted that we find no evidence of amorphous matter suddenly changed into complex structure, still why matters should be endowed with the plasticity by which it slowly acquires modified structure is unexplained. If we assume that natural selection, or the struggle for existence, coupled with the tendency of like to reproduce like, is the cause of organic production, and that the phenomena are at present unnoticeable as to why like should produce like, why acquired characteristics in the parent should be reproduced in the offspring. Reproduction itself is still an enigma, and this great question may involve deeper thoughts than it would be suitable to enter upon now.

Perhaps it may seem an argument in favour of continuity which could be presented to a doubting mind would be the difficulty it would feel in representing to itself any per saltum act of nature. Who would not be astonished at beholding an oak tree spring up in a day, and not from seed or shoot? We are forced by experience, though often unconsciously, to believe in continuity as to all effects now taking place; if any one of them be anomalous, we endeavour, by tracing its history and concomitant circumstances, to find its cause, i.e., to relate it to antecedent phenomena; are we then to reject similar inquiries as to the past? is it laudable to seek an explanation of present changes by observation, experiment, and analogy, and yet reprobate in the same mind its application to the slow history of the earth and of the organic remains embalmed in it?

If we disbelieve in sudden creations of matter or force, in the sudden formations of complex organisms now, if we now assign to the heat of the sun an action enabling vegetables to live by assimilating gases, and amorphous earth into growing structures, and regarding other phenomena hitherto unknown, do we not find we are not to apply the same method to the great periods of the world’s history, when the sun shone as now, and when the same materials existed for his rays to fall upon?

If we are satisfied that continuity is a law of nature, the true expression of the action of Almighty Power, then, though we may humbly confess our inability to explain why matters are impressed with this gradual tendency to structural formation, we should cease to look for special interventions of creative power in changes which are difficult to understand, because, being removed from us in time, their concomitants are lost; we should endeavour from the relics to evoke their history, and when we find that we cannot try to bridge the gap with more confidence. If it be true that continuity pervades all physical phenomena, the doctrine applied by Cuvier to the relations of the different parts of an animal to each other might be capable of great extension. All the phenomena of inorganic and organised matter might be expected to be so inter-related that the study of an individual would lead us to discover the relations of various other phenomena with which it is connected. As the antiquary deduces from a monolith the tools, the arts, the habits, and epoch of those by whom it is wrought, so the student of science may deduce from a spark of electricity or a ray of light the source whence it is generated; and by similar processes of reasoning other phenomena hitherto unknown may be deduced from their probable relation with the known. But, as with light, heat, magnetism, and electricity, though we may study the phenomena to which these names have been given, and their mutual relations, we know nothing of what they are; so, whether we adopt the view of natural selection, of effort, of plasticity, &c., we know not why organisms should have this *natura formativa*, or why the acquired habit or exceptional quality of the individual should re-appear in the offspring.

The sense of understanding is to be educated more gratifying than the love of the marvellous, though the latter need never be wanting to the nature-seeker. But the doctrine of continuity is not solely applicable to physical inquiries.

The same modes of thought which lead us to see continuity in the field of the microscope as in the universe, in infinity downwards as in infinity upwards, will lead us to see it in the history of our own race; the revolutionary ideas of the so-called natural rights of man, and a proving reasoning from what are termed first principles, are far more unsound and give us far less ground for improvement of the race than the study of the gradual progressive changes arising from changed circumstances, changed wants, changed habits. Our language, our social institutions, our laws, the constitution of which we are proud, are the growth of the past; the product of a process of continuous struggles. Happily in this country, though our philosophical writers do not always recognise it, practical experience has taught us to improve rather than to remodel; we follow the law of nature and avoid cataclysms.

The superiority of man over other animals inhabiting this planet, of civilized over savage race, and of the more civilized over the less civilized, is proportioned to the extent which his thought can grasp of the past and of the future. His memory reaches further back, his capability of prediction reaches further forward, in proportion as his knowledge increases. He has not only personal memory which brings to his mind at will the events of his individual life,—he has history, the memory of the race; he has geology, the history of the planet; he has astronomy, the geology of other worlds. Whence does the conviction to which I have alluded, that each material form bears in itself the records of its past history, arise? Is it not from the belief in continuity? Does not the worn hollow on the rock remind us of the action of water and wave, and the slow deposition by which it was formed, the organic remains imbedded in it, the beings living at the times these layers were deposited, so that from a fragment of stone we can get the history of a period of many millions of years? From a fragment of earth we may get the history of our race, not perfect, but not indifferent to tradition. As science has opened our eyes to the complexity of the earth’s surface, so may the history be extended and improved. Saturn’s ring may help us to a knowledge of how our solar system developed itself, for it as surely contains that history as the rock contains the record of its own formation.

By a patient investigation how much have we already learned, which the most civilized of ancient human races ignored! While in ethics, in politics, in poetry, in sculpture, in painting, we have scarcely, if at all, advanced beyond the highest intellects of ancient Greece or Italy, how great are the steps we have made in physical science and its applications? But how much more to know! We, Ephemera as we are, have been learned by transmitted labour, to weigh, as in a balance, other worlds larger and heavier than our own, to know the length of their days and years, to measure their enormous distance from us and from each other, to detect and accurately ascertain the influence they have on the earth, and carried out to discover the substances of which they are composed; may we not fairly hope that similar methods of research to those which have taught us so much may give our race further information, until problems relating not only to remote worlds, but possibly to organic and sentient beings which may inhabit them, problems which it now seems wildly visionary to enunciate may be solved by progressive improvements in the modes of applying observation and experiment, induction and deduction.
THEORY OF THE INFLUENCE OF FRICTION UPON THE MECHANICAL EFFICIENCY OF STEAM.*

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

1. Attention has been called to the fact that the heat produced by the friction of the pistons, piston-rods, and trunks of steam-engines must be wholly or partly communicated to the steam, and must thus affect the work of the steam and the expenditure of heat upon it. The object of the present paper is to point out how that fact, when treated according to the principles of thermodynamics, affects the efficiency of the steam.

2. The most general and elementary way of considering the subject is as follows:—Let $W$ denote the whole indicated work of the steam in a given time, including that which is lost through friction in the cylinder; let $F$ be the part of that work which is so lost, so that $W - F$ is the available work; also let $H$ be the whole expenditure of heat upon the steam in the same time, expressed in units of work by the aid of the first law of thermodynamics. Then $\frac{W - F}{H}$ is the efficiency of the steam when friction is not taken into account. If we take into account the loss of work through friction, but not the gain of heat, the efficiency is reduced to $\frac{W - F}{H}$. With respect to the gain of heat through friction, it is to be observed that if the cylinder is properly jacketed and protected, the whole of the heat due to the friction of the piston must be communicated to the steam, and that, if we consider the great superiority of slightly moist steam above air in conducting power, it is probable that a small fraction only of the heat due to the friction of piston rods and trunks escapes without being taken up by the steam also. If, then, we suppose that sensibly the whole due to friction in the cylinder is taken up by the steam, there is a corresponding saving in the expenditure of heat, and the efficiency of the steam becomes $\frac{W - F}{H}$.

3. For example, let the case be taken of an engine in which the steam is admitted to the cylinder at an absolute pressure of 40 lb. on the square inch, being 25°-31 on the square inch above the atmosphere, the back pressure being 4 lb. on the square inch, and the rate of expansion 5 lb. The efficiency of the steam in such an engine, neglecting friction, is about 0:12 = $\frac{W}{H}$. Suppose now that one-tenth of the indicated work is lost in friction in the cylinder, and that all the heat of friction is taken up by the steam; that is to say, let $F = 0:1 W = 0:012 H$. Then the fraction 0:012 expresses the saving of heat due to friction, and the efficiency in four heat units to have the following value: $\frac{W}{F} = \frac{W - F}{0:12 - 0:012} = 0:988 = 0:983$. The result of taking into account the loss of work, but neglecting the saving of heat, is $\frac{W - F}{H} = 0:108$.

4. The following is the result of applying the principles of thermodynamics more in detail to the process of expansive working as affected by friction. During any small portion of the process of expansive working let $d W$ be the total work done, including friction, and $d F$ the part of that work which is lost in friction; also let $t$ be the absolute temperature at which the work $d W$ is done, and $k$ the real dynamical specific heat of the substance. Then by the second law of thermodynamics, the expenditure of heat in any small portion of the process is $\frac{d H}{d t} = d t \phi$; in which the "thermodynamic function" $\phi$ has the following value: $\phi = k \log \frac{t}{d t} + \frac{d W}{d t}$.

If all the heat due to the friction is taken up by the working substance, let $d H'$ be the diminished expenditure of heat; then the thermodynamic equation of the process becomes $d H' = d H - d F = t d \phi - d F$.

And if, as is often sensibly the case, the work done in friction is a constant fraction $f$ of the whole work, so that $d F = f d W$, we have the following equation:

$$d H' = (1 - f) d H - d F$$

(C)

5. The special modes of formation of friction in saving heat during the working of steam in ordinary steam engines probably consist in a diminution of the additional supply of heat required by the steam while in the cylinder, in order to prevent the accumulation of liquid water there. It is known that during the expansive working of steam heat disappears; that part of such disappearance of heat (which is from one-fourth to one-fifth of it) takes effect in lowering the temperature of the steam to that corresponding to the diminished pressure; and that the remainder (being from three-fourths to four-fifths) tends to produce liquefaction of part of the steam. Such liquefaction is known to cause indirectly great waste of heat, through the distillation of the liquid water into the condenser, and consequent abstraction from the cylinder of heat, which has to be supplied by means of an increased expenditure of boiler steam. In order to realise, therefore, the economy due to expansive working, it is necessary to keep the steam during the expansion nearly in a state of dryness; and for that purpose it must be supplied with heat to the extent of from three-fourths to four-fifths of the heat which disappears during the expansion. That supply of heat may be conveyed from the boiler either by means of a steam jacket, or of superheating, or by both methods combined; and the heat due to friction in the cylinder, by contributing to that supply, diminishes the part of it which is necessary to obtain from the boiler.

6. The theoretical formula for the indicated work and the expenditure of heat in a steam engine working with dry saturated steam are as follows:—

Let the initial absolute temperature, absolute pressure, and volume of one pound of steam be denoted, during the admission into the cylinder, by $t_1$, $p_1$, and $v_1$; and at the end of the expansion by $t_2$, $p_2$, and $v_2$; so that $\frac{v_1}{v_2}$ is the rate of expansion.

Let $p_a$ be the back pressure of the exhaust steam in the cylinder, and $t_a$ the absolute temperature of the feed-water.

Let $a - b$ be the approximate value, in units of work, of the latent heat of evaporation of one pound of water at the absolute temperature $t_1$; the constants being as follows:

$$a = 1109550 \text{ foot pounds}$$

$$b = 540:4 \text{ foot pounds per degree Fahrenheit, or}$$

$$972:72 \text{ foot-pounds per Centigrade degree.}$$

Let $J$ be Joule's equivalent of the specific heat of liquid water $= \frac{1}{18}$ foot-pounds for Fahrenheit's scale, or 1380 foot-pounds for the Centigrade scale nearly.

Let $U$ denote the work done by a pound of steam, on the supposition that the back pressure is equal to the final pressure ($p_a = p_2$); and $W$ the whole indicated work done by a pound of steam.

Then $U = a \log \frac{t_1}{t_a} - b (t_1 - t_a)$

and $W = U + (p_a - p_1) v_1$.

Also the expenditure of heat per pound of steam is

$$H = U + (t_a - t_2) a (t_2 - t_a)$$

(F)

Now the total heat of evaporation of one pound of water at the initial temperature $t_1$, is

$$H_1 = a - b t_1 + J (t_1 - t_a)$$

and the difference between this and the total expenditure of heat is the additional heat which must be supplied to each pound of steam in order to prevent liquefaction in the cylinder, that is to say:

$$H - H_1 = U - (J - b) (t_1 - t_a) = a \log \frac{t_1}{t_a} - J (t_1 - t_a)$$

(H)

It appears by calculating numerical results in particular cases that $H - H_1 = 0:076$ from 0:76 to 0:8 U nearly.

(K)

0:76 being the co-efficient at high temperature, and 0:8 at low.

7. It is out of this latter part of the expenditure of heat $H_1$ that the saving is made through the heat produced by the friction in the cylinder. The following are four examples of the theoretical calculation of the work and expenditure of

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* For their demonstration see "Phil. Trans.," 1869, and "A Manual of the Steam Engine and other Prime Movers," p. 308; and for approximate formulae for practical use, see also "The Engineer," Jan. 3, 1866, p. 1; and "Useful Rules and Tables," p. 263.
heat per pound of steam, and of the efficiency, with and without allowances for friction —

No. of Examples.

Temperature — Fahrenheit.

<table>
<thead>
<tr>
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<th>I.</th>
<th>II.</th>
<th>III.</th>
<th>IV.</th>
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<tbody>
<tr>
<td>Initial, ordinary, absolute; ( t_1 = )</td>
<td>799</td>
<td>799</td>
<td>718</td>
<td>718</td>
</tr>
<tr>
<td>Final, ordinary, absolute; ( t_2 = )</td>
<td>709</td>
<td>664</td>
<td>637</td>
<td>612</td>
</tr>
<tr>
<td>Feed-water, ordinary, absolute; ( t_3 = )</td>
<td>104</td>
<td>104</td>
<td>104</td>
<td>104</td>
</tr>
<tr>
<td>Back pressure; ( p_4 = )</td>
<td>565</td>
<td>565</td>
<td>565</td>
<td>565</td>
</tr>
</tbody>
</table>

|    | Initial, \( p_1 = \) | 16580 | 16580 | 4854 | 4854 |
|    | Final, \( p_2 = \) | 4128 | 1768 | 988 | 2624 |
|    | Back, \( p_3 = \) | 814 | 814 | 814 | 814 |

| Volumes — cubic foot in the lb. | Initial, \( v_1 = \) | 3814 | 3814 | 1209 | 1209 |
|    | Final, \( v_2 = \) | 1400 | 3125 | 5992 | 2234 |
| Rates of expansion \( \frac{dv}{dH} \) | 3.87 | 8.2 | 4.46 | 1.96 |

Indicated work in foot-pounds per pound of steam, at pressures above the final pressure, \( W = \)

\[
83930 \cdot 132550 = 89000 \cdot 37800
\]

Do at pressures below the final pressure, \( W = \)

\[
49042 \cdot 34700 = 18140 \cdot 41900
\]

Total indicated work, foot-pounds, per lb. of steam, \( W = \)

\[
122972 \cdot 17050 = 107140 \cdot 79500
\]

Heat expended in foot-pounds per lb. of steam, before emission, \( H = \)

\[
689175 \cdot 859175 = 840139 \cdot 840139
\]

Additional heat expended in preventing liquefaction (without deduction) \( H - R = \)

\[
62778 \cdot 100633 = 69964 \cdot 29199
\]

Total heat expended (without deduction) \( H = \)

\[
921953 \cdot 969789 = 91013 \cdot 800278
\]

Efficiency without friction \( W \) = 0.9442 - 0.974 - 0.1176 - 0.0915

Suppose co-efficient of friction one-tenth, then work lost in friction and saved \( F = \)

\[
12297 \cdot 16705 = 10714 \cdot 7960
\]

Available work \( W - F = \)

\[
119873 \cdot 160345 = 96425 \cdot 71559
\]

Heat expended in preventing liquefaction, deducing that saved by friction, \( H - R = \)

\[
49481 \cdot 83918 = 82530 \cdot 2118
\]

Total heat expended, deducing that saved by friction \( H - F = \)

\[
908656 \cdot 942093 = 892359 \cdot 811328
\]

Efficiency, allowing for friction \( W - F \) = 0.933 - 0.0156 - 0.0173 - 0.0083

8. From the preceding formula and calculations it appears that although the heat produced by friction in the cylinder makes but a trifling saving when compared with the whole heat expended, it may become considerable when employed with that part of the expenditure of heat which is employed to prevent liquefaction of steam in the cylinder, and may thus co-operate usefully with the action of jacketing and superheating.

In reply to some observations by Mr. Smith and Mr. Bramwell, the latter of whom pointed out that the heat generated would be carried away in part by the exhaust, Professor Rankine said he was sorry that he should have explained himself so badly in his original paper as to lead Mr. Bramwell to suppose that he regarded the heat generated by friction as increasing the motive power. That was not what he had intended to convey. He was far from supposing that the heat generated by friction added in the slightest degree to the amount of the working power of the steam, or even made the diminution of the work less than it would otherwise be. What he meant to convey was that the effect which he had ascribed to the heat produced by friction was not a gain or saving of mechanical work, but simply a saving of a portion of the heat which, otherwise, he lost in preventing liquefaction of the steam. Whatever quantity of heat was produced in the cylinder by friction, precisely to that extent would the heat which it was necessary to supply by means of jacketing or superheating be diminished. Steam might be dried or superheated by wire-drawing, or passing through a small aperture without performing work. Most engineers, however, would agree with him that to dry or superheat steam by that method was not economical, and that the same object could be better attained by the direct application of heat.

ON THE DECAY OF MATERIALS IN TROPICAL CLIMATES, AND THE METHODS EMPLOYED FOR ARRESTING AND PREVENTING IT.*

BY GODFREY OATTS MANN.

The cause of the decay of materials in tropical climates, and of the means successfully employed to prevent such decay, must become an increasing matter of interest to the Engineer, as well as to the English capitalist, not only from the rapid increase of public works in India, but also from the connection of Great Britain with the extensive and rising empire of Brazil, with reference to which this Paper is especially written.

The climate of Brazil is the most agreeable of any within the tropics, either in the western or in the eastern hemisphere. This is especially the case in the Province of Pernambuco, where, probably, the temperature varies less than in any other quarter of the globe, as—

The average temperature in the night during the year is 64°. The average temperature in the shade during the rains is 78°. The average temperature in the shade during the hot season is 89°.

The highest temperature in the sun during the year is 148°.

The seasons, which, without doubt, influence more than the temperature the decay of materials, cannot be said to be so regular, as regards particular months, as in India, or as to the quantity of rain falling during the year. The annual rainfall varies from 30 inches to 120 inches. Thus, in 1860, 67 inches fell, whilst in 1861, the rainfall amounted to 123 inches. In some years the rains commence unusually early, continue for a month or more, after which there may be a month, or even two months of hot weather; when the rains again set in for a short, or a lengthened period. In other years the rains commence late, and last only a short time; or set in early, and continue for a long period, with intervals of days, or perhaps weeks, of sun, causing that peculiarity in the climate, excessive heat combined with much moisture, noticeable, more or less throughout the year, and which must be very trying for the generality of materials, more particularly railway sleepers, about which it is proposed first to treat.

The first lengths of the permanent way of the Pernambuco Railway were laid in February, or March, 1867, with creosoted sleepers of timber from the north of Europe. Fair average samples, taken out on the 1st December, 1868, show that the half round intermediate sleeper is in the most perfect state of preservation, in fact, nearly as good as on the day it was put down; while the square sawn, or joint sleeper has not withstood the effects of the climate so well. Although the square sleeper does not exhibit a very favourable result, there can be no doubt as to the advisability of sending out, in the first instance, to India, Brazil, or any other tropical climate in which a way is being made, the whole of the materials required for the permanent way, as the Engineers and the contractors' agents, are, in most cases, unacquainted with the qualities of tropical timber, and the locality is generally unable to supply timber of good quality, in sufficient quantities, for the rapid construction of a line. Even if the required quantity could be obtained, the natives are so well versed in the question of supply and demand, that the native timber quickly assumes the price of imported creosoted sleepers. It is evident, from a sample which had been laid nearly seven years before removal, that creosote will, if properly applied to suitable descriptions of timber, prevent its decay in tropical climates.

The points requiring consideration are, the quality and form of the sleeper, and the kind of ballast in which it will be most advisable to lay it. About 12 miles of the Pernambuco Railway are entirely laid with creosoted sleepers, principally in white oak. According to this description of the ballast, the half round intermediate sleeper has suffered, since the opening of the first section of the line in 1858, a depreciation of not more than 1 per cent., whilst the square sawn sleepers have experienced a depreciation of not less than 50 per cent. Had the latter been placed in wet cuttings, with ballast retentive of moisture, no doubt the whole of them would have required to be replaced. Hence it is evident, that the smaller and closer grained wood is much more lasting than the larger and more porous description; and that fine open sand ballast, which allows a free drainage during the rains, is best adapted for the preservation of sleepers in the

* Read before the Institution of Civil Engineers.
tropics. This has been satisfactorily proved in 10 miles of road laid with creosoted and with nativesleeper, in a mixed description of ballast, in which neither has stood so well as in the finished track itself.

As regards the form, the general opinion in Pernambuco is in favor of the half round, as it allows the water, during the wet season, to pass away more freely, than is the case with the square sawn sleeper.

In 1869, whilst on the work of the second section of the Pernambuco Railway, in progress, the Government Engineer Fiscal, Signor Manoel de Barros, advised the use of native sleepers; but, beyond giving a list of those timbers he considered suitable, he did not, in any way, assist the Company's Engineer with any facts as to the peculiarities of these timbers. The result was, that the wood was cut at unsalvageable seasons, and the process of the work being rapid, the sleepers had not time to dry, but were used in a perfectly green state, so that shortly after the opening of any section, the renewal of the sleepers had to be commenced. On the fourth and last section, this took place within a month after it was opened.

From this it might be inferred, that there does not exist in Brazil timber, either in quality or quantity, fit for railway purposes; but such is not the case, as there are numerous qualities of the finest wood in the world, and about as inextinguishable as the coal-fields of Great Britain.

The question may be asked, when has this supply not been made available? In reply, it may be said, that there is an entire absence of statistics or reliable information regarding the people themselves. They continue to employ what their forefathers used, and if it serves their purpose, they have the least desire to find out anything better, or more available. This seems to obtain in all tropical climates, so that the railway pioneer finds himself without data to guide him, and it is only after a residence of many years in any one of these countries, that personal and gradually acquired experience can guide the Engineer to a judicious use of the resources of the country, and insure his not committing any serious error.

Railway sleepers being a new feature in Brazil, the railway Engineer finds himself without the durability of the innumerable varieties of timber existing in the country. The result was, that scarcely two opinions were found to agree; ignorance or apathy in most cases influencing the information given. Consequently most unsuitable descriptions were used, which now (as previously stated), after being laid but a short time, require extensive renewals. The experience of the samples afford evidence, that there is wood in Brazil which will last for an indefinite period. The opening of the railways into the interior will doubtless bring this superior description of wood to the various sea-ports, as is now the case on the Pernambuco Railway, to the exclusion of all imported timber. The Author has known for seven years past, that properly selected timber of the country will be found more durable than any description of wood sleeper yet imported; and, as resident Engineer of the Pernambuco Railway, he is now employing these kinds in renewing the sleepers on the line.

In conclusion, upon the subject of native railway sleepers, it is found advisable, in order to prevent decay, to cut the timber during the dry season, to select large and full-grown trees, to remove the whole of the bark and sapwood, leaving the heart only, and not to expose the sleepers in the sun when first cut, but to stack them in open piles under cover, through and about which air freely circulates for a few months. These rules being attended to, the result will be satisfactory, as regards Brazilian timber, and it is reasonable to assume, that the same rules will apply, more or less, to timber in India, and other tropical countries.

The cost of sleepers delivered, subject to these conditions, at the rates of 2s. 7d. each, the scantling being sometimes 10 inches, by 5 inches, by 9 feet, but more frequently 12 inches, by 6 inches, by 9 feet. Imported creosoted sleepers have invariably cost double that amount.

From what has been said with regard to railway sleepers, it will be seen that timber in general requires in tropical climates, the greatest consideration in its use for permanent structures. Reliable information may perhaps be obtained, as to the best descriptions for general use: still the Engineer will meet with such a variety of opinions among the natives, that it is only after considerable personal experience, that he feels certain in using any description for particular purposes. Good timber suitable for building abounds in Brazil, in the greatest variety. Many kinds are impervious to the white ant, which is generally seen in the green timber, and especially if these are in contact with the earth. In dry places and with a free circulation of air, the white ant does not prefer timber thus situated; and it is found that roofs of buildings, of good and well-seasoned native wood, resist, for an indefinite period both the climate and the white ant.

Creosoted timber, as is well known, resists the attacks of the white ant; but the close grain of the particularity of tropical timber renders any attempt to creosote it all but useless. North American pitch-pine also stands exceedingly well the attacks of the white ant, when used in the roofs of buildings, or in any locality not humid; but it is found after a time, when laid upon the earth, to lose its resisting powers, as well as to become subject to rapid decay.

White, or yellow, pine can only be used in the tropics for doors, movable window frames, bodies of railway wagons, or other work intended to be kept in motion. Its use even for these purposes is questionable, as the white ant has such an affinity for it, that a door or a window which has remained shut for a few weeks, will almost invariably be attacked by that insect. Generally it will be best to select suitable native wood for all permanent works. Since the opening of the railway in Pernambuco, timber can be brought 70 miles or 80 miles from the interior, and be delivered of any practical scantling, at the rate of 1s. per cubic foot.

Since the establishment of the gasworks in Pernambuco, the Brazilian Engineers and constructors have adopted the practice of paying over, with coal tar, the ends of all timbers built into the gables of buildings, or in any other position in which it is burned, on the premises, and thus excluded from the air, and so far apparently with beneficial results.

The oldest samples of native timber that could be obtained accompany this paper, and are part of the piles, taken up during the month of November, 1863, of the old Recife wooden bridge, constructed in 1814, and now about to be replaced by an iron bridge, under the direction of Mr. W. Martineau, (M. Inst. C. E.) It is only necessary to add, as regards this part of the subject, that to insure satisfactory results, it will be essential to select the quality suitable for any particular description of work, to see that the wood is cut at the proper season, and, to prevent its splitting, not to expose it to the sun when first cut; to have the bark and sapwood removed, and to allow it to dry a certain time before being used. With these precautions no foreign timber will be found able to compete, in the tropics, with that of native growth.

Upon iron bridges, from their increasing adaptation, any information as to the result of their use in tropical climates must necessarily be valuable. The Author will not be allowed to discuss, as each may be said to be equally liable to decay. There is, however, one great defect in the construction of some of these bridges, that is, suspending the transverse girders by bolts, instead of allowing them to rest on the main longitudinal girder. When the two plans are compared, the most usual observer must give the preference to the latter, particularly where iron is so subject to rust if not properly treated.

Iron bridges in the tropics will, if proper care be taken in the first place, and ordinary attention be bestowed upon them afterwards, last for an indefinite period, whether on the sea-board or on the continent. In the last column of Horace Green and Co., there are no other iron bridges than those of the Pernambuco Railway, four of which, when examined, showed the following results:—In these bridges the piers are formed of four cast-iron pipe pile, each 15 inches in diameter, to which were afterwards added two cylinders, each 3 feet in diameter, having the usual side of angle iron, and side brackets to the girders, an addition that was found necessary after the line had been opened for traffic. The superstructure, in most cases, is composed of Warren's girders.

The first bridge over the Pirapaima River, about 16 miles from the city terminus, consists of two spans of 80 feet each. The
iron piles below the water level were found to be coated with a thin layer of mud, similar to that of the bed of the river. When this was washed off, the piles appeared to be in a most perfect state, not at all rusted, and when put into the water, they did not rust, nor did they show any sign of rust when first put down. The bolts and nuts connecting the piles, the wrought-iron tie-bars for bracing the columns, as well as the whole of the upper structure, were also found to be in the most perfect state. The water in this river, although affected by the rise and fall of the tide, is at all times fresh, both near, and for some distance below the bridge. The second bridge consists of three spans over the Saboatao, a tidal river, which at the site of the bridge is salt, or more or less brackish, except at the lowest tides, when it is sometimes found to be fresh. Here the piles under high water were covered with small marine shells, not to any great thickness, and caply been removed when the red paint was taken to be in perfect as when first applied. The iron itself did not seem to have been in the least affected. The wrought-iron bracing bars, 3 inches by ½ inch, were not in such good preservation, rust being observed on them after the shells were removed. The whole of the upper structure was in a good and satisfactory condition.

The next bridge that came under examination was one of five spans, over the mouth of the river Ibarra, at the head of Recife Harbour; and the fourth and last of six spans, over the Capilbarbe, a few hundred yards from the former, and as the result in both was exactly alike, they may be jointly described. At the time of the examination, the water of the river being nearly dry, so that the pipe-piles could be examined down to the sand. The whole of these were densely covered with oysters from 6 inches to 12 inches thick, and the first ones had adhered so firmly to the piles, that on breaking them with a hammer, portions of the backs of the shells remained, requiring a chisel to get them off. When these were all removed, it was satisfactory to find that the piles were perfectly sound. These shells appear to act as preservatives to the metal, by excluding the air and the sea-water. There is no doubt further examinations will prove, that these shells afford probably the best protection that can be put on, and therefore ought not to be removed. The wrought iron bracing bars in these bridges, do not, as may be expected, show so well as the cast-iron piles. A sample from the end of the bar attached to the pipe-joint below the water line accompanies the Paper. It will show to what extent these bars have been affected, after being erected about six years, as well as illustrate how the shells adhere to the piles. The upper structure of these bridges was found to be in the best possible condition, and the result of the examination on the whole was very satisfactory.

It may probably be necessary in a few years to renew some of the wrought-iron bracing bars, as well as some of the bolts and nuts under water. When these require renewing, it will be advisable to use steel in place of wrought iron, as that material will not have endurance as long as the bridge lasts. The result of six years experience is certainly but a short time upon which to form a decided opinion; but it would appear, that the cast-iron pipe piles are likely to last for a considerable period, and that the upper structure of wrought iron, with ordinary care and attention, is likely to stand well. The only parts apparently affected are the wrought-iron bracing bars and the bolts and nuts below high-water mark. These may in future be made of steel, with but little additional expense.

No specific measures hitherto have been employed, or to have been considered necessary, for the preservation of iron bridges sent to the tropics. Red lead, or any other description of paint that came to hand, appears to have been used, and no consideration seems to have been given to the condition, or state of the iron, before painting. There is a tendency to keep the iron dry, after the sea-voyage, owing to the high temperature and the 'steamy' state of the ship's hold, rust is formed underneath the paint; the latter rises in blisters, then bursts, and falls off in large flakes, exposing the bare iron, highly oxidised, without a vestige of a paint remaining. This not only takes place with bridge-timbers with low, but with high quality wrought-iron tanks, &c., when sent out completely painted. No doubt the same care is bestowed upon them as when intended for home use, but it would be better not to go to this expense, as it only entails further outlay in a short time, to scrape the whole off and commence afresh. Care should be taken, in every description of work, that the iron be perfectly dry before the paint, or any other composition, is laid on. After trying a variety of paints and varnish, the best result was obtained in the preservation of the iron bridges on the Pernambuco Railway, and so far apparently with good success. From the result of its application in several other descriptions of work, the Author does not hesitate to recommend its use as the most efficient protection for bridges and iron work in general for the tropics. In order to prevent the great effect of corrosion, or incipient oxidation, on the surface of the iron, it will be advisable to have the whole of the smaller parts of the bridge-work, &c., before being sent away for shipment, heated to a low temperature, by passing them through a furnace or otherwise, then brushed and dipped in tar. The larger parts, which it would be inconvenient to heat, should be well cleaned, and the par lacquer as hot as possible. Tar of course can only be employed where it is decided to continue its use for the future preservation of the bridge. With public bridges, or in any situation where ornamental painting is considered necessary, linseed oil may be used instead of, and in the same way as, tar. Over this, and for further protection, a thin coat of zinc paint may be laid. This will stand the sea voyage, and when the bridge is erected, it can be cleaned off, when the ironwork will be ready to receive the finishing coat, which should also be of zinc, as all other paints for tropical climates are perfectly useless.

It is to be hoped that tar, linseed oil, and zinc paint, will all shortly be superseded by the excellent 'chunam' of India, good stone-work in these climates is the most likely to last, with the least outlay for repairs. Stone ought never to be lost sight of by the Engineer, whenever its use is at all practicable. Abutments for bridges will, of course, be built of this material when it is obtainable, and, as previously stated, where it is obtainable. The most satisfactory material for the foundations of cast-iron piles. Stone has never been extensively used in or about Recife, owing to its being found only at a considerable distance from the city. It is imported from Portugal, for facing the churches. These, and a few old Dutch works of the seventeenth century, show how well this material stands the decay of the influence of the tropics. It need scarcely be said, that no mistake can possibly be made in allowing it to enter freely into the construction of all public works in these climates.

Bricks, when stone cannot be obtained, must of necessity be used for certain descriptions of work. Great caution should be exercised in their selection, as it is found that all bricks made in the Brazilian ports, with sea-water wash, are more or less susceptible to the weather, and mould rapidly away when exposed. It is, therefore, advisable to make them at some distance from the coast, with fresh water, and above all to have them well and thoroughly burned, which, in these climates, where fuel is generally expensive, is most difficult to insure. Near to the seacoast, it is found necessary to protect all brickwork with plaster, which certainly serves its purpose exceedingly well. In the interior of the country well-burnt bricks may stand for a few years, but ultimately it will be necessary to plaster them, or to give them a thick coat of whitewash from time to time. Tar, or whitewash, has been used in America, and perhaps, in a few cases, for the protection of brick buildings, and other works of this material; and in localities where it would not be considered unsightly, it is certainly preferable in buildings on the side from which the prevailing winds and rains set in during the wet season, as it not only throws off the moisture on the outside, but also decreases the influence of the tropics. It need scarcely be said, that the moisture any other outer protection. Of two samples of brick taken from the same wall, built in 1790, in Recife, although not in any way protected by plaster, or lime whitewash, one appears to be quite perfect, while the other is rapidly decaying, and shows the necessity of outward protection, as a general rule, on large structures, obtaining, in large quantities, thoroughly well-burnt bricks.

Tiles, in Brazil, are almost invariably of the form shown in the specimens, and are made of similar material to, though where obtainable of better clay, than the bricks. When well burnt,
and of a good shape, with sufficient overlap when laid on the roof, native tiles answer their purpose exceedingly well, and being thin, and invariably burnt in ovens, this process is so effectually performed, that the weather seems scarcely to affect these tiles, even under the most unfavourable circumstances.

Laths are in nearly all cases made from the sapwood of one of the hardest and most durable timbers in Brazil, *Imbertiba.* A chisel, or axe, is introduced into the end of the stick of timber, about 4ths of an inch from the outer edge: very little force splits it in the direction of its length, allowing the fingers and hand to be introduced, and the lath is left off, retaining an uniform thickness, with a breadth of from 2 inches to 2½ inches.

Permanent-way keys, cut from native timber, have, since the opening of the Pernambuco Railway in 1858, been used for renewals, and with success. The timber, being of a remarkably close nature, has not shrunk after use, as the imported keys are liable to do, and although the interior of the key is not the chief necessity for creosote. In fact, with some keys kept constantly in creosote for three months, when sawn through the centre, the oil only appeared a little below the surface.

Railways are oxidised considerably when left near the sea-coast. It will therefore be advisable, in the construction of a line, to remove them into the interior, as soon as it is convenient to do so. When in use, in whatever locality, the motion of the trains appears to prevent any considerable amount of rust from forming. There is, however, a matter for serious consideration, as regards permanent-way rails in the tropics; and that is their tendency to flatten, or laminate, after being subject to the wear and tear of driving engines and trains for a short time. This is no doubt owing to the high temperature during the greater part of the day, and the constant passage of the trains when in that state. The remedy appears to be, the substitution of steel, or steel-faced rails, and engines as light as the traffic of the line will allow. Whilst on the subject of engines, it may be well to notice the rapid wear of the wheel tires in the tropics, particularly on lines like the Pernambuco, with numerous curves. Where it has been found necessary to adopt steel tires, in addition to an arrangement for keeping the leading wheels wet when going round curves, there is a small pipe from each pump to the front upper side of the leading wheels, made so as to open and close at pleasure, to ensure their being wet. Although this arrangement answers exceedingly well, in saving the flanges of the wheel tires, as well as in causing the engine to work round any curve much easier, still this can only be looked upon as a desirable expedient in existing engines. The bogie should be used with all engines made for tropical climates, where the rails are so constantly hot and dry. The saving in the rails, as well as in the wheel tires, would be considerable, and there would be greater safety in working, as it is found that the dryness tends to make the leading wheel-flanges grip, and, when a bad joint occurs, mount the rail. Clamps and spikes do not require any special notice, as, with the exception of the former not being so liable to breakage, owing to the absence of frost, these need not, in any way, differ from those used in England.

About 10 miles of the Pernambuco Railway are laid with Greave's 'pot' sleepers, as to the durability of which in the tropics, the iron, when found to be too rigid, is fixed in fine sand ballast. Had these sleepers been used on the deep banks when first formed, the usual subsidence during the rains would have caused considerable breakage, and in any case much more ballast would have been required than generally falls to the share of railways abroad when first opened. A portion of the line actually laid has, however, although considerably improved, by introducing the ordinary fish plates, with four bolts, and suspending the joints. The easiest method of doing this is by cutting away about 15 inches of the first lengths of rails, knocking out all the keys, and then drawing the rails in succession 18 inches back, by which the joints are brought into the centre between the joint and the next intermediate sleeper, the 'pots' remaining undisturbed. The fish plates are then put on. The 16-inch pieces are always kept at hand to be introduced to allow for the passage of the trains. This work was done by the piece, and cost 1d. per pair of joints.

The carriages of the Pernambuco Railway are made with a strong wrought-iron under frame. The body is of teak, the inside lining is also of this material, the outside panels are of 'papier mâché.' After six years' hard work and exposure to sun and rain, these carriages are in excellent preservation. The material employed for the outside panels has proved in the highest degree suitable for the tropics, and will probably be generally adopted when its good properties are known. But whether 'papier mâché' or timber is used, the panels should be well painted and varnished, or the sun would be fast to destroy them. The first carriages sent out to Bombay for the Great Indian Peninsula Railway, with panels of varnished teak, split after being exposed to the sun for a short time, whereas in the 'papier mâché' panels on the Pernambuco Railway, there is not a crack in any of them after six years' wear and exposure.

The railway wagons for the Pernambuco Railway were constructed in Brazil, the iron work having been sent from England; the under frames are made of native timber, and the body of white or yellow pine. The great heat of the sun is found to dry up and cause the sides, and particularly the roofs, of these wagons to become leaky. The sand has therefore been used as an outer covering for the roofs, and will no doubt answer. For the tropics, the most serviceable covered goods wagon will be found to be one constructed with an iron underframe and a light galvanised iron body.

In conclusion, there is no doubt that the subject of the Decay of Materials in Tropical Climates, and its prevention, is but little known, though deserving of being thoroughly investigated. It is hardly to be expected, that any one individual will be found to possess the information necessary to treat upon this subject with reference to all tropical countries; but it is to be hoped that some Member will take the trouble to compile the results obtained from experience, and produce a work which will not fail to be acceptable to all who take any interest in these countries, and particularly India.

APPENDIX.

A.

List of Brazilian Timbers suitable for and now being used as sleepers on the Pernambuco Railway:—Sicupira, Oiticica, Almececa Brava, Garrobo, Guandá, Fag, Sao Filipe, Angelim Amargoso, Sapucia de Filho, Amarello Vinhático, Macununamba Preta. Tao present price of the above, for sleepers, 10 inches by 5 inches, by 9 feet, delivered at stations on the line, is 2s. 1d. each.

B.

List of Brazilian Timbers suitable for general purposes in permanent structure:— Sicupira Asso; Sicupira Meirim or Verdelheiro; Sicipira Acari; Oiticica; Garrobo; Fag, Sao Filipe; Sapucia de Filho; Sapucarnana; Macununamba; Imbertiba; Siquira; Fag de Carro; Barubá. These cost 1s. 6d. per cubic foot, and are of great durability, and resist the white and excepting in the sapwood.

The following are durable as the foregoing, and resist the white and even in the sapwood on account of their bitterness:— Angelim Amargoso, Arraboa, Pinto (Garrobo) and Pitta (Marfim). These also cost 1s. 6d. per cubic foot. Coocó, Borbão de Velha and Aruaca do Sertão, are very durable, and resist the white ant; but are not to be found of any considerable extensions. These cost 1s. 8d., as do Parahiba and Cedro, which are very suitable for boarding, their strong smell and their great bitterness repelling the white ant. The price of Louro Choireco and Louro Ti is the same. These are of a porous description, to be laid doors up, and, as the lime has no taste, owing to its smell; the heart of the Ti is very strong and durable, resisting the white ant. For Amarello Vinhatico and Amarello Verdelheiro, the cost is 1s. 14d. per foot. They are of great durability, and are extensively used in cabinet work.
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### PARIS UNIVERSAL EXHIBITION, 1867.

The works in the Champ de Mars are proceeding with great rapidity; the whole of the framework of the iron portions of the building may now be said to be completed, and the outer circle which masks all within, the grand nef, as it is called, and which is to form the machinery and processes court, including in the latter manual as well as mechanical labour, presents a very bold and commanding appearance. There is little or no ornamentation connected with this exterior circle, or rather zone of the building, but the huge sides of plate iron, eighty feet high (walls there are scarcely any apparent), look light and elegant, in consequence of the clerestory, or range of windows, in three compartments, with arched tops, which occupy all the upper portion between the great pillars of the inner as well as the outer side. This grand nef is nearly a mile round, more than a hundred feet in width, and above sixty feet in height, and will certainly form one of the noblest exhibition galleries ever constructed; the roof being unpierced, and the light coming in from the upper part of both sides, give this noble court an importance, as regards appearance, which a glass roof would be far from producing; there is plenty of light, without the cold or hot glare of a glazed covering. The clerestory, as already stated, occupies the whole of the upper portion of the sides; the corresponding spaces below are filled with brick and plaster work, and in front is the alimentary court, in which all the cafes, restaurants, and other places of refreshment are to be placed; beyond this again is a jutting roof, forming a covered promenade, twenty feet wide, which lines all round this outer circle of the exhibition. The grand nave is being rapidly covered in, and a large number of the window frames, the only portions of the zone which are in cast-iron, are in their places; when viewed from the park, beyond the gigantic proportions of this great court, its curved outline, and the fan-like appearance of the marquise, or veranda, produce an admirable effect, and show how much may be done without any extraneous ornament, by the mere repetition of simple elements, when good proportions are maintained throughout. The Commission has wisely determined not to mar the symmetry of this outer face of the building by any attempt at architectural effect in the way of porticoes; there will probably be an entrance to the park of an ornamental character on the side of the quay, and opposite the main door of the building, and there will be many elegant structures in the grounds themselves, but these will all be at a sufficient distance from the building itself not to produce an unpleasing contrast with its bold, simple features.

The inner zone of the building, divided into two courts, a wide one for the Fine Arts, and one of smaller dimensions for the retrospective museum, or gallery of the Histoire de Travail, is, as has been stated in the Journal, formed of solid stone walls, with partly glazed roofs. The whole of the masonry has been finished for some time, many of the sections into which these two courts are divided are roofed in, and some have the glass in its place and the walls plastered. The salles of the Fine Art gallery, which occupy the straight sides of the building, are noble rooms, admirably lighted, but those which occupy the circular ends, and which form by far the largest portion of the whole, will give, we fear, a great dissatisfaction, the walls pre-senting curves of small radius, the light falling in the most perplexing manner. In this inner zone of the building the curved form is a sad mistake. Between the great outer portion and the inner zone which we have just described, are the intermediate galleries, to be devoted to raw materials, furniture, clothing, ornaments, hardware, and all the remaining classes of the catalogue; the light cast-iron columns and partially glazed hands of a very pleasant character, and they are useful as a very pleasing element of the building, but if it be the design of this portion, from its larger radius and the absence of division walls, improves its appearance. These intermediate courts are the most advanced of all; the roofs are being glazed, the louver boards are in place, and in a few weeks they promise to be ready for the exhibition.

The central garden, like the exterior of the building, will have an iron marquise, or veranda, all around it, but in a different style. This is nearly finished, and consists of a light and elegant cast-iron facade, supported by slender columns, whose plinths rest on steps raised above the garden level. A large number of buildings are rising up in the park. In the first place there is a very large plain building, of three stories, on one side, communicating with the park as well as with the road without; this is to be devoted to the use of the juries, and probably in part to that of the Imperial Commissioners also. This building has been covered in for some time and will shortly be occupied. Opposite to this, on the other side of the Quay d'Orsay, is another large building, not so far advanced, which is for the purpose of a club, to include all the ordinary features of such an establishment as far as they may be required for its temporary purpose, and also a large exchange or hall, for the use of exhibitors and those with whom they have business transactions. In another court again, is a small ecclesiastical edifice, of which the roof is now nearly completed, and which is intended for the exhibition of all kinds of church furniture and decoration, interior as well as exterior. With this view the model church is provided with a transept, an apsis, a number of small chapels, and a profusion of windows. The latter part is to contain the works of that part in which all objects of ecclesiastical use or decoration may be exhibited in an appropriate setting is said to have originated with M. Leveque, a well-known artist in stained glass, of Beauvais, who, with the sanction of the Imperial Commission and the aid of exhibitors and others, has raised this model Gothic church, which covers a thousand square yards of ground, and, which, no doubt will glisten next spring in all the splendour and with all the taste for which French artists, decorators, church, jewellers, and others are so conspicuous. It is an excellent idea, likely to be well carried out.

Another building is to be raised by order of the Vicerey of Egypt, to contain a large number of copies of the most celebrated monuments of that country, besides other objects of art and curiosity.

In one corner of the park considerable works are going on for the formation of the horticultural and piscicultural exhibition which will form a large garden, with cascades and aquariums on a large scale.

Outside the precincts of the Exhibition, the railway station of the line which will lead direct to all parts of Paris as well as, bring into communication all the lines starting from the city, is nearly completed, and the railway works in connection with it are being pushed with the utmost energy, the line to the Quay d'Orsay, which will afford a direct entrance to the park from the landing place on the bank of the river is constructed, and the ornamental portions are now being completed; and lastly, the large space of ground in the Isle St. Germain, intended for agricultural experiments, and other subsidiary purposes, is laid out and arranged. This ground is about a mile distant from the Exhibition.

Amongst the features talked of, but whether decided upon we are not informed, is the formation of a terrace on the top of the grand nef of the building, with ascent and descent by means of hydraulic lifts, from which a bird's eye view may be obtained of the park and the surrounding country.
The publication of the catalogue has been ceded to M. Denut, the well-known bookseller of the Palais Royal, for the sum of £20,320; the catalogue is to consist of twelve parts, the first to contain the plans, tables, and documents relating to the exhibition; the second is to be devoted to the history of labour, or rather, of work; and the other eight, to the eight other great groups into which the general contents of the exhibition is to be divided. The entire work is to be sold for five francs, and the separate parts at half-a-franc each.

The lists of intending exhibitors in many of the classes are now complete, and some idea may be formed of the show which will be made to the French side of the Exhibition. Classes 14 and 15 unified, artistic furniture, upholstery, and decoration, numbers 220 exhibitors; class 17, porcelain, faience, and other artistic pottery, 68 exhibitors; class 18, carpets, tapestry, and other tissues for furnishing purposes, 62 exhibitors; class 21, goldsmiths’ work, 39 exhibitors; class 22, bronze, fine iron castings, and repoussé work, 101 exhibitors; class 23, objects in fine leather and basket-work, and other small wares, 90 exhibitors; class 27, cotton fabrics and threads, 241 exhibitors; class 32, Shawls, 28 exhibitors; class 34, hosiery, linen, and small articles of dress, 170 exhibitors; class 35, clothing, 218 exhibitors; class 36, jewellery and other ornaments, 159 exhibitors; class 37, other small wares, 93 exhibitors; class 44, leather, skins, and furs, 84 exhibitors; class 62, prime movers, generators, and machinery specially adapted to the purposes of the exhibition, 12 exhibitors; class 54, tool-making machines, 111 exhibitors; class 58, materials for printing and the manufacture of papers, 142 exhibitors; class 69, paper, paper-making, dyers’ and printers’ fabrics, and tissues, 80 exhibitors; class 60, machines, instruments, and processes of ordinary trades, 52 exhibitors; and class 62, saddlery and harness, 41 exhibitors. The classification differs so much from that of the former Universal Exhibition held in Paris, that it is impossible to make a comparison of the numbers; in the former there were only 27 classes, not including the fine arts; in the latter there are 95 classes, or, excluding the fine arts, 91. If we take the twentiue classes of which the number of exhibitors are given above, as a fifth of the whole, we shall arrive at nine or ten thousand, which is little short of the total number of works for the Paris and the colonies; there is no doubt, however, that the exhibition will be far in advance of its predecessor; and if, as is understood, the admission jurors have, in accordance with the principles laid down by the Imperial Commission, set up a much higher standard of admission than formerly, a diminution of the number of exhibitors will be an immense advantage to the public. It may be taken for granted that there will be no space to spare on the French side of the exhibition, and that the quality will be in keeping with the quantity. In looking over the lists many important names are not missing, and certainly the trades for which Paris and its neighbourhood are celebrated will be well represented and the remaining groups, such as the cotton and hosiery trades, and there is no doubt that, whatever may be the number of exhibitors, the productions will show not only a considerable advance since 1855, but even since 1862. Since the preceding was written the list of admitted exhibitors in the class of manufacturing machinery has been inspected, and it appears that they amount to very nearly four hundred, and include the first firms in the empire.

The Imperial Commission attaches great importance to the tenth and last group in the classification adopted, namely, that which has for its object the improvement of the physical and moral condition of the population. The group is divided into seven classes, devoted to:—Materials and methods of infant education; books and materials for adult education; furniture, clothing, and food, distinguished by utility combined with cheapness; popular costumes of various countries; specimens of cheap, convenient, and healthy houses; productions of all kinds, manufactured by working men, having their own shop, and only assisted by their own apprentices; and the methods employed by these little masters; forming together a complete economical exhibition.

As regards the products of master workmen, the Imperial Commission desires to see represented an important phase in the life of existing men—that in which a man has arrived by his talent to the position of small master, and may hope at some future day to be at the head of a large establishment.

The class will include all kinds of productions, the only general characteristic being the conditions of their productions. Working men in visiting exhibitions have often seen the admiration of the public excited by the productions of their own hands, but which bore no trace of their name, and regretted that they could not exhibit objects of credit or quality at their own homes; or, rather, perhaps, it should be said, that special facilities were not afforded them for that purpose; the Commission has therefore created a class in which every object shall be the production of an artisan, with or without the aid of his family and an apprentice, either for regular trade or sale.

It is with the last three that we must be occupied, in the hope of showing under the name of the manufacturer who has arranged for their production and assured their execution, but in the class under notice every article will reveal the hand of the actual producer.

Many small masters, who work at home for manufacturers, have feared to give offence to their employers by exhibiting on their own account, but the new classes introduced into the programme of the coming exhibition have sanctioned by the manufacturers who take part in the management, so that it is hoped all jealousy will be done away with; and the object in view has been made known by various means of publicity in all parts of the empire, and special committees have been formed in the Departments, as well as in the capital, to carry out the project.

The productions in question are to be submitted to five committees of admission, and the whole of the articles accepted for exhibition will be exhibited previously, and privately, in the Palais des Industries. The Imperial Commission, in the Imperial Exhibition, bearing the expense of their display in the preparatory exhibition, but the exhibitors paying for their own fittings in the Universal Exhibition itself. In order to make place for this preliminary exhibition, and for other operations connected with the exhibition, the collection of Algerian and colonial products, and all the fittings used for the exhibition of cattle, are now being removed from the building in the Champs Élysées. The Offices of the Imperial Commission are at present in this building, and some departments will be retained there during the whole time of the exhibition, and this, with what we have stated above, shows how valuable it is to have such an editor, so ready to undertake the preliminary and supplemental service of a great exhibition like that of the coming year. It should be mentioned, too, that in order to assist working exhibitors as much as possible, it is arranged that, in case of large articles, a deputation from the committees of admission will examine them in the workshop of the manufacturers.

The works of fine art intended for the exhibition of 1867, limited to such as have been produced since 1855, are also to be collected in the Champs Élysées building, by or before the 15th of October; the jury of admission will commence its examination on the 19th of November, and announce its decisions by the end of December. Great haste has been made, and the very early dates fixed for this examination, as the works received for exhibition will thus be lost to their owners for twelve months, and it is feared that these regulations will have a damaging effect on the art portion of the exhibition; certainly five months seems a long period for selection and arrangement.

As regards foreign countries, much of the anxiety that was felt a short time since has passed away. It is certainly to be feared that the manufacturers of Bohemia, Moravia, and other countries, will not make such a show as they would have done had not the war interfered with all their operations, but both Austria and Italy have supplied the Imperial Commissions with the plans of their space and the list of their exhibitors. As regards Spain, the government has formally announced its intention to take part in the exhibition, and has supplied its plan and a list of exhibitors, and intends to erect in the park some structures of considerable extent and importance. The Spanish Commission has issued pressing circulars to the local representatives on the subject.

The war in Italy will probably have an unfortunate effect on her manufacturers, but the Italian Commission has furnished the designed for the façade of its portion of the building, and is about to commence its constructions in the park, and that in every way; it is represented. Its section will be characteristically decorated with a façade in ornamental work, composed of pine wood, and bearing the
escutcheons of the twenty-two cantons. She will have, amongst other things, curious archaeological and ethnographical collections, and a complete series of the picturesque costumes of the country.

Egypt will present a very remarkable exhibition; a quadrangular building, with a colonnade all round, about 85 feet long by 40 feet in width, will contain some of the most curious objects of art and antiquity in the country. This building will be a reproduction of the Ptolemaic temple dedicated to Hothor, with the greatest possible exactitude in all the details, and the execution of it has been entrusted to the learned Mariette Bey. Amongst the most interesting monuments are those of the Viceroy and his wife, who are offered up to the gods, by Ptolemy, an authentic likeness of the famous Cleopatra, found by Mariette Bey last winter in a cavern at Denderah; bas-reliefs of various handicrafts, classed according to date; artistic representations of the epoch of the pyramids; the bas-reliefs from the tomb of Phihot hotep (Saqquara), representing the deceased surrounded by his people, hunting scenes, combats of lions and buffaloes, fêtes and dances; bas-reliefs from the tomb of Ti, with scenes of rural life and labour; representation of various trades and arts, the navigation of the Nile, and other subjects, under the various dynasties; reproductions of the famous bas-reliefs and paintings of the Two Tombs of Ayed and Djeser, with a number of original statues and works of art, coffers and other objects. In addition to this large building, there will be two others illustrative of modern Egyptian life—one representing the habitation of a fellaheen of Upper Egypt, with a small establishment for artificial hatching, a stable of domestic animals, and a carpenter's shop. There will also be an ethnographical collection; the other a horseshoe-shaped kiosk, in the purest Arab style, surrounded with plants and flowers of the country.

Outside of the kiosk native Egyptians will be seen practising the trades of the present day. In the interior of the kiosk will be a display of the trade of Egypt, which is expected to foster the exhibition, and an Oriental café, furnished with all its accessories. In the court will be a large plan, in relief, of the whole of Egypt, executed by order of the Viceroy, and under the direction of Colonel Mircher, the chief of the French mission in Egypt, and in the centre a fountain, composed of the alabaster of the country.

It will not be out of place to conclude this notice of the coming exhibition with the results of an inquiry into the sanitary condition of the mass of workmen employed on the works on the Champs de Mars. It appears that there has been no great agglomeration of population in the neighbourhood. Down to the 1st of April the number of persons employed did not exceed 800, but since that period it has increased to 1,477. Of these 472 live in distant quarters of the town, 300 belong to the establishment of Mar, Cali and Co., and make part of the resident population of the quarter in which the works are situated, and that of the whole number only 438 form an addition to the neighbourhood. The lodgings of these last, have been frequently visited, and found to be in a satisfactory condition as regards health; and as the greater portions of these men are masons, whose work is finished, 300 of them have already been discharged. The result is, that the accumulation of this large number of men on one spot has not given rise to any notable change in the condition of the quarter. This is owing to the number of artizans and the quantity transported, and, as already stated, very much increase as greater facilities for communication are afforded.

All this merchandise, between the East and the West is carried by two main routes—the nine-thousand-mile route round the Cape of Good Hope, and the six-thousand-mile route by the Mediterranean. The general proportion of that by the shorter route, being conveyed in the vessels of the celebrated Peninsular and Oriental Company. To show the magnitude of the operations of that company, which has been established for a quarter of a century, I may remark that it has a total capital of £2,348,000, with a surplus, which is £500,000 Reserve in its Treasury. The imports were for the twelve months ending the 30th September, 1865, amounted to £2,138,000. The insurance, carry and purchase the same, at approximately £375,000, leaving a net profit of £1,259,000; and the chairman stated at the last half-yearly meeting of the Company, which gives a very good notion of the extent of their operations, viz., that the rise in the price of food had affected...
them very materially, because they had no less than "ten thousand stoppages in thirty days." The navigation of the Company for the twelve months extended over 1,600,000 miles, and they possess altogether a magnificent fleet of 63 vessels, with a Customs' measurement of 92,353 tons, and 18,270 horse-power. Some idea also may be formed of the increase of traffic which we may expect from Eastern countries if I state what is now occurring on the railways in India. Less than 3,500 miles of railway. The two principal lines are the East Indian Railway, running from Calcutta to Delhi, with a branch under construction to Jubbulpore; and the Great Indian Peninsula Railway running from Bombay to Jubbulpore in the north-east and from Bombay to Madras in the south-east. Of the latter railway, Jubbulpore will be the terminus of the line from Calcutta to Delhi, which has cost about £29,000 a mile, 1,200 miles are completed, and the traffic has reached from £28,000 to £40,000 a week. The Great Indian Peninsula Railway from Jubbulpore and Madras has only been half completed, about 624 miles being open for traffic; but that line is being constructed at the lower figure of £18,000 a mile, while the week's progress this year amounts to as much as, and in some cases even exceeds, that on the East Indian Railway. In fact, the traffic on the Great Indian Peninsula Railway has nearly trebled itself as between some of the first few weeks of last year and the corresponding weeks of this year; and if the receipts go on at the present rate, it promises to exceed that of the best previous years in India, but not of the best paying railways in the world.

When this line is completed to Jubbulpore on the north-east, and to the Madras Railway in the south-east, and when the East-Indian portion is completed to Jubbulpore also, there will be complete railway communication between Bombay and Calcutta over the whole line. From Bombay and Madras, and these lines being main routes, Bombay will necessarily become the port of India. In dealing with my subject, therefore, I shall consider the two ends of my grand route as being England and Bombay. That route naturally divides itself into two parts, the one part being from England to the east of the Mediterranean, and the other part from the east of the Mediterranean to Bombay.

Of the different routes between England and the east of the Mediterranean, the first which claims our attention is that by sea from Southampton to Alexandria, which is 3,000 miles long, and which occupies about thirteen or fourteen days. There can of course be no shorter a passage than this. It is, however, necessary to go as far as Alexandria, and a short detour from there will lead to the great sea-routes of the Mediterranean. From Alexandria we go to Suez, and from there to Suez, on the other side, will be about forty-two miles long. It is from beginning to end a difficult line, in an engineering point of view. There are many other tunnels on it besides the "Grand Tunnel," which has not yet been thought worth while to commence. The gradients are as steep as in 2½ miles; and even half through the tunnel. The summit of this tunnel will be at an elevation of 4,500 feet above the sea, and the total cost of this 42 miles of railway will be £5,750,000.

The excavations in the tunnel is carried on by machinery, worked by men of considerable skill, and cost the tunnel and a small distance from them. The tunnel, a mile and a half of large water-wheels, by the action of which the air is compressed to a pressure of five atmospheres; and the compressed air being taken into the tunnel through a pipe, is used at the face of the excavators to work a most ingenious machine, which was originally contrived by Sommellier, Grand-St. Grotton, and which has now been working there for some years. There are nine jammers working against the rock, kept in motion each by two cylinders, the one cylinder causing the jammer to twist round, and the other propelling it forward. They thus imitate the action of jammers worked by hand, and bore holes ten, or twenty, or thirty inches deep, according to the nature of the rock. Then other holes are bored, and when a sufficient number have been made, the machine is run back 200 or 300 yards, and powder is inserted, and exploded, in the usual way. As soon as the explosion has occurred, the material is thrown into wagons, and run back as rapidly as possible; and the machine is brought again, and set to work as before.

But there are some difficulties with regard to ventilation. About 200 yards behind the machine there is constantly a dense column of smoke and the products of combustion; and in walking into and out of the tunnel you find practical experience on this point by which your clothes, face, and hair are discoloured. It takes from 3½ to 4½ hours to clear a tunnel out, and purify the air, when no work is going on. It did so, at least, when I was in the tunnel last spring. They were then progressing at the Median end at the rate of as much as one metre and a-half per day; but since then they have come, as was then expected, to very hard, solid, quartz rock, and they are now working with great difficulty. As lately as this season, their progress lately has been at the rate of half a metre a-day. There is believed to be about 500 metres of this quartz rock, followed by compact limestone, which will, it is expected, be more easy
to deal with. Looking to the quantity and quality of rock to be bored through, and to the rate at which the work will probably progress, it may be estimated that this tunnel will not be completed, perhaps, for six or seven years.

In any case, the time required to take to complete this tunnel, the idea has been conceived of constructing a temporary railway over the top of the Mont Cenis. There is a very good road over the mountain, along which it is proposed to lay this railway. The total elevation of the pass is 7,000, and of the mountain 11,000 feet. When Mr. Fell went three or four years ago, he found it too steep for any ordinary railway worked in the usual way, and he was therefore obliged to adopt a new system, the principle of which I will now explain. In ordinary railway working we trust, as you are aware, to the adhesion between the vertical driving wheels of the engine and the bearing rails of the permanent way, as the means by which the steam-power is applied to propel a train. And in order to get extra adhesion to take heavy loads up steep gradients, we are obliged to increase the weights of our engines, and the number of their driving wheels, in proportion to what we require. But in mounting a gradient of 1 in 12, with bad adhesion, such as you are liable to on the Mont Cenis, sometimes with a gradient of tenth, or even one fifteenth, an engine, ever so heavy, would only be able to take itself up, with perhaps a very light train. So Mr. Fell threw off extra weight, and made the engine partly of steel; and he has employed for extra adhesion, a central rail, running between you and yourself, so that the wheels on the engine to bite upon it, and so pinch their way up the incline. His second engine weighs 17 tons, which, added to 24 tons of pressure between his horizontal wheels and middle rail, affords a total adhesion of 41 tons; and it will do the work, therefore, on steep gradients and slippery rails, of an ordinary engine in onefifth of the time which it will take an engine of 40 tons, without being killed—so to speak—by its own weight.

Mr. Fell first tried this system,—which was patented so far back as 1820, but had never been reduced to practice,—at Whaleybridge, with the assistance of Mr. Brassey, in this country, and the experiments there were so successful, that he then applied to the Mont Cenis, where one engine, with a gradient of 1 in 12, which has been worked for many months with great success. About 20 minutes’ walk above Lanelouburg, where the ascent of the Mont Cenis commences, he has constructed a mile and a quarter of railway, on the zig-zags of the steepest part of the mountain. The steepest gradient on it, is 1 in 12, the average gradient attains to 1 in 25. The engines are very simple, with axles on only 40 mètres, or 131 feet, round the corner of the zig-zag. On this experimental line, with his second engine, he has taken up a weight of 16 tons, which is equal to 60 passengers with their luggage, at the rate of 8 miles an hour; and there is no doubt he will be able to run without any difficulty for the 48 miles which the line will have to cover, though at times by rounding them from the cable of adhesion; and by the rotation of these drums in the cable of adhesion, the "locomotive" machine winds itself and draws its train up the incline.

There would be serious difficulties in the application of this system to very high mountain passes, in consequence of the 48 miles of work to be done, and the gradient will be 1 in 25, with a descent of 1 in 25, by snow and ice; and you have not the safety in such a system that may be derived from the central rail. Another important point is that under the system of Signor Agudio and very sharp curves which are necessary on the railway over the Mont Cenis are impossible.

The route which we must now consider is the Trieste route. This is 260 miles shorter by sea, but 369 miles longer by land than the route by Marseilles; and, therefore, it may be rather a quicker route. But now that railways have been constructed down to Brindisi, few people will be inclined to take the Rhine instead of the Adriatic route, as it may be by land to Constantinople. Another difficulty about both routes at present is, that even as soon as you reach Constantinople, you have a very difficult country again to cross through Asia Minor; and it will probably be some time before railways are made through those countries.

The route, then, by Italy is the quickest route which we have any immediate chance of using. The railway over the Mont Cenis will probably be brought into use in the course of next year; and I may say that it is under the consideration of Government to send the Indian mails by Italy if they can make proper arrangements for, as regards the railways and harbours.
I now turn to the other side of the map, to the route from the east of the Mediterranean to Bombay. The route from Suez to Bombay is about three thousand miles long. The navigation is difficult, and at times very disagreeable. By way of improvement to this route, the Suez Canal is, as every one knows, now being constructed. M. Lesseps proposes to make across that isthmus a ship-channel seventy-two miles long. He neglects the routes taken by the old, wide, and winding course of the Nile through different branches of the Nile, and goes straight across from Port Said in the Mediterranean, to Lake Timsch (which was dried up until very lately) half-way, and so on to Suez. The channel of this grand ship-channel is to be twenty-six feet deep, one hundred and ninety feet wide at the top, and one hundred feet wide at the bottom. He has already constructed a road or small canal, about six feet deep from Port Said to Lake Timsch. The part from Lake Timsch to the Red Sea has hardly been commenced, or at all events very little has been done upon it. But a sweet water canal has been constructed from a place called Zagazig, from a branch of the Nile towards Lake Timsch and nearer it, and from the Great Eastern branch of the Nile to the Mediterranean Canal to Suez. This sweet water canal is nearly finished, sixty feet wide and six feet deep; but it is about nineteen feet higher than the Salt water Canal; and he has by means of locks connected the two together. He is able thus to convey boats, by using the rigole to Lake Timsch, and the sweet water Canal to Suez, from the Nile to the Red Sea. There is little doubt, I think, that the great energy of M. Lesseps, and the credit of the French Government, who are backing him up, will lead to the completion at some time of this canal. But there are still great difficulties to be encountered on parts of it. The foundations are in some places very bad, and as fast as he digs out the mud and sand, so fast does the excavation fill up again. He proposes to make walls all along the sides; but to get foundations for those walls will be exceedingly troublesome, and they will take a great deal of time and money. He has also, which are less difficulties, very high hills to advance up and to go through. He is energetically going about this in a very energetic way, for I heard not long ago of a hundred steam-dredges having been ordered to Egypt for the excavations. With these he intends, no doubt, to compensate as well as he can for the want of the forced labour, of which at first he had the advantage, but which he has since been deprived of. Twenty of these dredges were to be ready landed from the Nile; that was obliged to put back into Falmouth in distress. They were constructed to work to a depth of about twenty feet, with portable engines, so that when the dredges had done their work the engines might be employed for other purposes.

There has been much political feeling on the subject of this canal, and steam-dredges were to be ready landed from the Nile; that was obliged to put back into Falmouth in distress. They were constructed to work to a depth of about twenty feet, with portable engines, so that when the dredges had done their work the engines might be employed for other purposes. But it will certainly, if it is completed, be of much more use to us than to any other nation; and I think that we ought to feel very much obliged to M. Lesseps and the French Government, for expending so much money in the hope of making it for us. As long as we have command of the sea it will be entirely at our mercy at both ends; and it will, if it is completed, give us a most excellent ship route to the East, by connecting our Southampton and Mediterranean route with our Suez and Bombay route. But it is a question whether it will ever be of much use to sailing vessels in consequence of the difficult navigation of the Red Sea.

The Egyptian Government also have an idea of making a railway 1,700 miles long, from Suez to Cape Guardafui. Such a railway may be important for Egypt, but I doubt whether it would ever be of much avail for British traffic, because it is a long line, about twice as long as another and a better, to which I should have direct point, and it would bring us out at the western side of the Arabian Sea.

The next and last, but by no means least important route which I have to consider, is that by the Euphrates Valley. The first discoverer of that route may fairly be said to have been Alexander the Great, who marched from Egypt to the Valley of the Euphrates and so grand so grand in the interest. But conquered Persia, took possession of India, sighed for more worlds to conquer, and returned with the remnant of his sickened army, after a march of nearly 20,000 miles, to die in the Lamlam marshes. Many others have since followed or attempted to follow his example, and it is well known that the Great Napoleon, when he went to Egypt, had an idea of doing the same—of wrestling India from us, and conquering the East; and he would, no doubt, have endeavoured to carry out the project, if we had not intercepted it in the beginning.

This route was reconnoitred by General Chesney in 1830, when he made a most enterprising and interesting voyage of 700 miles, with an interpreter and a servant down the Euphrates. £20,000 was afterwards voted by Parliament for a regular survey of this route, which was made, under General Chesney's command, by Sir John Menzies and others. We have been glad to learn recently from General Chesney, that the Treasury have authorized the publication of another volume of his proceedings. The result was a proposal to make a harbour about three miles to the south of the Orontes river, and they chose, as the best route for a railway that by Antioch and Aleppo, down the Euphrates, on to Baghdad, and so to the Persian Gulf. The harbour was to cost £350,000, and the railway about £6,000,000. They found that the route would be an easy one. There were a couple of bridges required over the Orontes river, and some cuttings between the Orontes and Aleppo; but the line from Aleppo down to the Persian Gulf was slated to be principally over water, and would present every facility for a railway. There is a steamer already running between Basrah and Baghdad. The navigation through and from the Persian Gulf would be far superior to that from Suez to the Red Sea; and there remains the possibility of ultimately completing the communication by railway from Baghdad to Bombay by rail.

By the adoption of this route we should save about 800 miles of distance, and several days of time. There can be no doubt that it is a most important route, in a strategical as well as in a commercial point of view, for ourselves as a nation. We should have the command by sea of the two ends of it, in the Mediterranean and in the Persian Gulf, and we should be able by its aid to connect our forces in Europe more intimately with our armies in Asia— to unite them for any operation immediately between Great Britain and India, and to reinforce Great Britain from India, or India from Great Britain, within a fortnight, which is a matter of great importance.

Mr. Bancroft, in a speech that did not exhibit much delicacy the other day in America, accused us of having constructed a chain of forts from Madras to Ceylon. But what we really want is, in a military point of view, is a chain of forts along the route of the Euphrates Valley from England to India. There is an idea that we should not need to have any force on the seat of war in the power of the inhabitants in making such a line; but it is said by others, on the contrary, that as Englishmen we should on the whole, be well received, while if the Turks attempted themselves to construct the railway they would meet with great opposition—that it would be looked upon in the one case as an undesired advantage, and in the other as a necessary precaution.

The ultimate route, then, that we should look forward to, practically, at the present time, is that through Italy and by the Euphrates Valley. By this route we may hope to go some day about 6,000 miles in a fortnight.

In concluding, there is another most interesting feature to which I would direct attention. Every reader of prophecy must regard a map of this sort with great interest, when he remembers the predictions that are not yet fulfilled. One can hardly look at it, indeed, without observing that it points in both directions, from the east and from the west, towards the Holy Land. We see and know that the Jews have been and are now scattered from that promised land among all nations; and judging from the completeness with which the prophecies with regard to their banishment have been fulfilled, we may be quite sure of the punctuality with which those prophecies will also be literally fulfilled which speak so plainly of their return. May it be with us that in laying out and establishing these routes between England and India, we are really doing something more—that we are contributing in an important degree to fulfil the designs of Providence. Who can read the passage in Isaiah, "Every mountain shall be a highway for my people," without thinking of all the summit roads and easements that are required? We are surely in some measure assisting to pave the way for the return of that people to the land to which they will "fly ere long as a cloud, and as the doves to their windows," bringing their silver and their gold with them, and which land they are destined on their conversion to inhabit and to enjoy in future generations.
ON TREATMENT OF MELTED CAST IRON AND ITS CONVERSION INTO IRON AND STEEL BY THE PNEUMATIC PROCESS.*

By Mr. Robert Musket.

In the year 1816, my father, Mr. David Musket, took out a patent for the manufacture of refined iron direct from the blast furnace.

For this purpose he erected a small blast furnace, 30 ft. high, blown by means of three tuyeres, with a pressure of blast of about three pounds and a-half per square inch. These tuyeres were arranged so as to dip down upon the surface of the melted iron in the furnace, and the blast passed through the hearth full, the tuyeres were partially below the surface level of the melted iron. There was no difficulty experienced in keeping the melted iron in a liquid state in the middle of the hearth, but round the sides the refined iron chilled, and formed what is technically termed "scull," and this rendered it very difficult, and sometimes impossible, to tap the furnace and run off the portion of the metal which retained its fluidity. When the tapping took place, the metal flowed from the furnace intensely heated, and throwing off the most brilliant scintillations. The temperature of the metal, like that of ordinary refined metal, was far higher than that of pig iron produced by the coke process, and from oxygenation, from working off the blast excessively. The pigs of metal obtained were perfectly solid, showing, when broken, a dense white steely grain. They were so strong as to bend before they broke, and occasionally they could not be broken at all, though struck by the heaviest sledges wielded by the most powerful man; the metal was, in fact, crude cast steel, and could be chipped with a cold chisel, and, when removed from the furnace, was susceptible of being forged at a low heat to some extent. The defect in this process was that, as in the refinery, the waste of metal was excessive, owing to the surface action of the blast upon the melted iron for a prolonged period. The difficulty of keeping the hearth open, and of tapping, arose merely from the small size of the furnace and hearth, and the weakness of the blast. The iron was, however, decarbonised, so as to be in the condition of crude cast steel, too highly oxygenated, however, to be forged into bars of commercial value.

The experiment I have described was, I believe, the first practical step taken in the improvement of the pneumatic process, though it was certainly not undertaken with any idea of producing either malleable iron or steel by that process, but simply a highly decarbonised refined metal. About the year 1850, I made experiments with some very highly-blown refined iron from the Parkend Ironworks, in the Forest of Dean, and found that, when alloyed, this refined metal could be forged into sound bars of very hard steel, too hard, indeed, for any practical purpose, but, nevertheless, solid, and free from seams or flaws, indicating that the iron could be sufficiently decarbonised whilst in the melted state, steel of marketable quality might be obtained by simply adding some metallic manganese to the decarbonised metal.

In the autumn of 1863, Mr. Henry Bessemer read a paper at the meeting of the British Association in Cheltenham, which, whilst it filled the scientific as well as the practical world with astonishment, did not in the least surprise me, except in the one circumstance of its being possible to maintain a tuyere beneath a heavy column of melted cast iron. That, indeed, appeared to me most surprising, since I was well aware of the highly destructive action of the iron slag which is generated by the action of atmospheric air upon melted cast iron. However, what I considered impossible had actually been accomplished by Mr. Bessemer, and the first great advance towards rendering steel as cheap as iron had been inaugurated by that gentleman.

Mr. Bessemer’s process consisted in forcing air through melted cast iron by means of tuyeres situated beneath the surface of the melted iron. When melted cast iron is subjected to this process, the silicon contained in the iron is freed and combined with the oxygen of the blast, which, passing to the surface as a light, frothy, grey slag. Next, the carbon of the melted iron enters into combination; and, lastly, the iron itself is attacked and consumed with the development of an intense temperature, sufficient to keep the iron, though freed from carbon, in a perfectly liquid state.

When the silicon and the carbon have been nearly or wholly eliminated from the cast iron operated upon, the product obtained is either crude cast steel or iron, according to the degree of decarbonisation arrived at. Ingots cast from this metal are more or less unsound, and, when forged, they frequently crack owing to their being too hard. This is, however, a difficulty met with in the requirements of commerce. Moreover, whenever the melted cast iron operated upon contains sulphur and phosphorus to any notable extent, the decarbonised iron is found to be so crude and brittle that it cannot be forged at all, and is, in fact, less valuable than the pig iron it has been made from. Hence, only the best coke pig iron or the Forest pig iron, and those suited for Mr. Bessemer’s process, and these are comprised in the hematite pig iron, the Forest of Dean pig iron, the Weardale spathose iron, and the Blanavon and Pontypool Welsh brands; these latter two being, however, far inferior to the other brands for the pneumatic process.

Mr. Bessemer naturally feared that he should be able to produce both cast steel and iron by his process alone, and it by no means detracts from his merits that he happened to overlook the fact that iron exposed in the melted state to the action of oxygen becomes as it were deabsed. Some persons term it "burnt iron," but I call it "oxygenated iron," and "oxygenated iron" is one of itself considered, and appraised as such. This oxygenation can be prevented when a metal is present whose affinity for oxygen is greater than the affinity of iron for oxygen, and it can be remedied when such a metal is subsequently added to the oxygenated iron. When Mr. Bessemer read his paper, I foresaw all the difficulties he had to encounter, and I knew that the remedy was simple and attainable, provided a suitable metal could be found at such a cost and in such quantities as would render its use practicable on the large scale. Out of several metals possessed of the required properties, I selected the metal manganese, found abundantly in the spiegelisen or spathose hematite iron of Rhenish Prussia, red combined therein with carbon and iron, the iron forming a convenient vehicle by means of which I could introduce the metallic manganese into melted decarbonised iron treated by Mr. Bessemer’s process. My first experiment was with some Bessemer metal prepared at the Victoria Ironworks from hematite pig iron. The experiment was made in small crucibles containing only a few ounces, the Bessemer metal being melted in one crucible, and the spiegelisen in another; the melted contents of the crucibles were then mixed, and a small ingot cast. This ingot was forged into a bar of excellent cast steel, which was doubled, welded, and made into a bar of excellent steel.

In the summer of 1865, I commenced working with the Bessemer process on a large scale, and I then proceeded to cast steel and iron, and, in a short time, large ingots of Bessemer steel were produced. The Bessemer process, therefore, as I have already said, was not in its earlier stages, and I was not then possessed of the patent for its use. In 1866, I had it in contemplation to go to the patent office to obtain a patent for it; but I found that a patent for it had already been secured by Mr. Bessemer, and I was willing to allow him the use of the principle to which I had adhered. I have never been asked to pay for the use of this patent, and I have always been allowed to work it without restriction or any charge.
who have benefited by its use under a moral obligation to recognise my claims to remuneration; for although by the accident of the non-payment of the stamp duty my invention became public property, I still think that that accident ought not to debar me from the reward that I am morally entitled to, and could have commanded to a large extent, but for the oversight on the part of whom I relied.

Much remains to be done to extend the use of the pneumatic or Bessemer process to the ordinary brands of pig iron at present considered to be unfit for this purpose. I am, I believe, in possession of the requisite knowledge to accomplish all this, and I am only waiting the opportunity to do so, whenever the Bessemer Company, with whom I have associated, shall consider that the proper time has arrived for them to erect a suitable Bessemer apparatus at their works.

The means are, I believe, as simple and efficacious as is the addition of spiegelisen, now invariably employed by all Bessemer’s licensees in England, and the resulting advantages will be proportionately great.

In Sweden, the Bessemer process has been carried out by operating upon certain brands of Swedish pig iron containing a considerable alloy of metallic manganese; the result is, that, with the subsequent addition of a little of the same manganese pig iron, of spiegelisen, is produced steel of moderate quality, but too speedy and unsober to be of much value for tools, and not nearly so tough and strong as the Bessemer steel made in this country from our own coke pig iron, and it can never enter into competition with our English Bessemer steel. In treating molten cast iron by the pneumatic process, the simplest plan is to deprive the iron of the whole of its silicon and carbon. In this case, the addition of a given weight of spiegelisen, or of any similar metallic compound of iron and manganese containing carbon to a given weight of descarbureted cast iron, will ensure results of tolerable uniformity as to the hardness or temper of the steel produced. The effect of adding spiegelisen to Bessemer metal is as follows:

The metallic manganese, by its superior affinity for oxygen, de-oxygenates the decarburised metal, and renders it sound and free from shorredness.

The carbon of the spiegelisen softens the mixture, and improves it for forming soft iron or hard steel is required.

The iron of the spiegelisen adds to the weight of the charge, and may, therefore, be considered as a gain to nearly the amount of its weight.

The silicon which is found in spiegelisen has the effect of reducing the boiling or agitation of the pneumatised metal when poured into molds, and is therefore beneficial, and it is not present to any injurious extent in spiegelisen.

The hardness or temper of the Bessemer steel may be increased at pleasure by increasing the dose of spiegelisen.

When spiegelisen is added to Bessemer metal containing sulphur, and the pneumatic blast is turned on so as to eliminate the sulphur of the spiegelisen, a portion of the sulphur of the pneumatised iron is carried off by the manganese, and thus, by repeated additions of spiegelisen and subsequent eliminations of its manganese, pneumatised cast iron may be wholly desulphurised.

In a similar manner, Bessemer metal containing phosphorus may be desphosphorised by employing titan pig iron in repeated doses to eliminate the phosphorus, and when both sulphur and phosphorus are present, both may be eliminated by repeated additions of spiegelisen and titan pig iron, the pneumatic blast being turned on after each such addition made to the pneumatised iron.

The pneumatic process of Mr. Bessemer, in conjunction with my spiegelisen process, is producing a revolution in the engineering world, and in all the departments of art dependent upon engineering, to an extent almost incredible, and the magnitude of its ultimate effects it is impossible fully to foresee. Mr. Bessemer will be remembered in connection with this, the greatest metallurgical invention the world has ever seen, and I venture to hope that I may not be wholly forgotten as having supplied the link which was wanting to render Mr. Bessemer’s process what it now is. As I have had much experience in matters relating to the steel manufacture, it was not surprising that I should at once have been able to devise the remedy for the one solitary defect which marred the success of the pneumatic process at its outset.

RAILWAYS AND COMMUNICATIONS IN RUSSIA.

RAILWAYS have been for some years the object of special attention to the Russian government. The surveys of projected lines, as well as the works of those in execution, are receiving at the present time a fresh impulse. St. Petersburg, Moscow, and Warsaw are already in communication with each other; and Eastern Prussia and Berlin may be reached by Gumbinnen and Elbing. More towards the south, the main line will connect those of Cracovia, leading to the two Prussian Silesias; and before long the southern line, which at present is opened from Odessa to Balta, will communicate with Bessarabia, a province bordering on the Boumanian principalities, and communicating with the Lemberg railway in Galicia. Another central line, running from Moscow to St. Petersburg, which is intended to unite the capital, Moscow, Orel, Koursk, Kharkov, Nicholasf, Sebastopol, and Taganrog, and to put the Gulf of Finland into communication with the Crimea. The southern part of this line is intended in the east to fulfill the same purpose as that of the Odessa-Balta in the west, viz., that of bringing to the two ports of exportation, Taganrog and Odessa, the wheat of Kovero, of Poltava, of Eupator, of Knerson, and of Podolia. A branch from the Balta line would no doubt run north-east towards the central part of the Urals. In a few weeks the trunk lying between Moscow and Serpoukhoff will be opened for traffic, and as far as Koursk next year. Suppose Russia could bring about a solution of her difficulties from the Baltic to the Black Sea, she has railways that lead, or will lead within a little, to the frontiers of all her neighbours, from the Pruth to Niemen. Other interior and transversal lines, such as those of Riazan, of Nijni Novgorod, are of great utility, but none more worthy of interest than the two following, intended to form the double communication between the Caspian and the Black Seas. The first of these lines, which is but twenty leagues in length, is in full work. It begins at Tzaritzin, an important town situated on the right bank of the Volga, which falls into the Caspian, and finishes at Kalatcheff, a town on the left bank of the Don, which falls into the Sea of Azof. The second of these lines is due to the energy of the Grand Duke Michael, Governor-General of the Caucasus. A line of railway is likewise intended to unite the port of Poti, on the Black Sea, with that of Bakon, on the Caspian Sea, passing by Koutsis and Tifiss; the line follows principally the valleys of the Rion and the Kour. For the last two years six thousand soldiers have been employed under the direction of Mr. Baillie, an English engineer. The port of Poti is now the site of important works, which will make it the principal port of the Black Sea in these parts. Besides this, the organisation of a direct service of steamboats with Constantinople, and the establishment of a good carriage-road between Tifiss and Tauris, is in contemplation. The exportation of merchandise from Mesopotamia is still probably follow the Russian lines, and it may be foreseen that the Transcausian line will almost completely absorb in these parts the traffic between Europe and Asia.

References.


The work before us consists of sketch plans and views of a considerable number of large residences, together with memoranda descriptive of the proposed kind of construction, and intended to aid in the preparation of complete specifications. The work, however, does not aim at so complete an illustration of the subject as to enable the builder to be carried out without professional assistance. The sketches are executed in a clear and effective manner, and several of them are highly picturesque, while others are broadly and simply treated. The style generally used is more or less medieval in character; such as combines well with the irregular levels of sites and the varied outlines of country scenery. The materials intended to be used are chiefly those which may be most available in localities where the houses are to be erected, and contain several useful combinations of rooms, and are such as the architect may advantageously study. The views being in perspective, give that clear and ready idea of the grouping of parts which is valuable to architect and amateur alike.

This is a useful addition to the many works on the not easily exhausted subject of English residences, rural and suburban.
BURLINGTON HOUSE.

The space of ground at the back of Burlington-house is apportioned between the London University and the Royal Academy, and the former has commenced operations. Trees are felled, and the bowling-ground for the foundation is occupied. The majority of Burlington-gardens which falls to the University will give a spacious, and yet quiet and secluded frontage towards Cork-street and Burlington-street. Mr. Penneathorne's designs for the building, with the exception of some final details, are now prepared. He had, in the first instance, presented to the Lord John Manners, at the request of the First Commissioner of Public Works, the design ultimately adopted was made. The style is transitional. The elevation consists of a centre and two wings; in the latter are two spacious lecture-theatres; the examination-rooms, &c., occupy the main body; the entire ground plan covers an area of about 290 feet by 150 feet. The treatment, though allied to Italian Gothic, is yet independent and individual: no one model in Venice or Lombardy has been implicitly followed; on the contrary, the whole design has been adapted to exigencies of climate, demands of utility, and the resources of local materials. For the marble architecture of Italy will be substituted a stone architecture, which may be more in keeping with immediate surroundings, and the cheaper and ruder material will be so employed as to secure polychromatic display. The adopted Gothic, too, admits of varied sky outline: a steep roof, and a couple of lofty campaniles will present a bold profile. The parlour on the first floor is estimated at £20,000; the restaurant £10,000; and the hall, in last session as a first instalment. The remaining moiety of the gardens, that adjoining Burlington-house, has not yet undergone any marked change under the hands of its present owners, the Royal Academicians. It is understood that the Academy will avail itself of the advantages offered by the Government. One of the body, Mr. Sydney Smirke, is entrusted with the making of plans for new galleries. Under present arrangements, the façade of Burlington-house, which the Institute of Architects and their President, Mr. Beresford Hope, made efforts to save, will remain intact. The effective Doric or Palladian colonnade, however, that rounds off the area on the side next Piccadilly, and which some deem the best part of the architectural composition of the celebrated amateur, the Earl of Burlington, appears still in danger. The works are committed to the care of Mr. Pennethorne, Mr. Sidney Smirkes, and Messrs. Banks and Barry.

ST. JOHN'S CHURCH, WOLVERHAMPTON.

The church of St. John, Wolverhampton, is a noble specimen of the style of architecture which prevailed in England a century or so ago, after the Wren revival, which is about the date of its erection. A font of beautiful proportions has just been erected at the west end of the centre aisle, and has been so designed as to harmonise with the character of the building, without strictly following the rules of orthodox classic detail. The main form of the font is circular, flanked by four columns of rich Devonshire marble, having capitals of the Corinthian type, conventionally carved. In the base of these are introduced the rose, lily, passion flower, &c.; while a corresponding enrichment encircles the stem of the bowl itself, and serves with the base mouldings to give variety to the effect. Above each of the four pillars is a cushion, containing a Maltese cross and other devices, executed in different coloured marbles; and around the rim, in the spaces between these panels is inscribed the following text, in incised letters—"One Lord, one Faith, one Baptism." Below this text, a belt of inlaid marbles, composed of giotto and Irish green, in patterns, with jewelled centres of sappar, crystal, and malachite, surrounds the bowl, and adds greatly to the blending of colours and richness of the effect. The general material of the font is Caen stone; and it stands upon a red Mansfield-stone step, round which plain, coloured, and glazed paving tiles are laid down geometrically in the aisle, which has been widened at this spot for the purpose, so as to form a suitable platform for the whole.

The work throughout, with the exception of the carving, which is by Farmer, of London, has been very carefully executed by Messrs. G. and P. Higham, of Wolverhampton, from the designs of Mr. J. Drayton Wyatt, Architect, London.

ON THE HEIGHT OF ROOMS.

SIR,—Permit me to offer a few remarks upon Mr. Croll of his very inconsequent formula in your last number. I fear we owe it to his unbounded admiration for the cube, and that it is this which has misled him into stating that the height of a room should in all cases be the square root of its area; for this is far from being about B. L., &c., amounts to. He comes closest by saying, "If therefore the four sides together with the top and bottom of a room be made equal each to each, the proportions thereof will of course be perfect." I am convinced that such a room, as is here given us as a model of perfection, is really of the worst form possible; and as I deny the advantage claimed for it, I deny also the justice of his formula made to affect all other cases. Indeed as far as the plan is concerned, I consider no room should be less in length than four-thirds of its width. But allowing the rule to pass, let us assume the area of a room to be 4900 square feet, then by the given formula we have the height $\sqrt{4900} = 70$ feet. Now let us take some dimensions which will accord with our given area—

\[
70' \times 70' \]

\[
98' \times 50' \quad = 4900 \text{ square feet.}
\]

\[
160' \times 28'\]

Surely Mr. Croll would not have us believe that all these rooms, whose areas are equal to 4900 square feet, should be of equal height. I think that he must admit that a picture-gallery, 26 feet wide by 200 feet long, such as was the water-colour gallery at the 1862 Exhibition, would have been unnecessarily high at 70 feet.

Lastly, why does Mr. Croll after so carefully embodying his theories, make such an unfortunate choice of examples?

Does he consider that Sir Charles Barry would have improved the House of Lords had he made the height 63-65 feet; and does he think that the fact of raising the roof 32-17 feet would amend the proportions of Guildhall? or does he perhaps intend to show that an average difference of only 47 per cent. between the works of these distinguished men and the results by his formula proves that they unconsciously adopted it? I am, &c.,

18, Hyde Park Gate South.

GILBERT B. RIDDLE.

September, 1866.

Waste of Coal.—Welsh mining engineers estimate that over thirty per cent. of coal is lost in mining. Much of it is in fine dust. There are patent processes to make it into blocks; but their costs is so great that they are little used. In Scranton, Pa., the coal-dust is a great nuisance; and there is much dust in all coal yards. Being bailed in attempt to work up coal dust into lumps, the question is whether we cannot adapt furnaces to burn this dust. We have seen it burned by blowers, but a rude way, which is of little use, but this is not the method mooted. What we want is a process that burns it well, and with a moderate draught. This, we think, can be done by sifting the coal into the upper part of the furnace, mixed with air. The coarser particles will fall upon a fine grate, through which there will be a regulated draught; but the dust will burn as it falls, and never touch the grate. We have seen carbonaceous powders burned while suspended in air, and they flashed like gas; an intense fire may be made in this way if skill be exercised, and the problem is to proportion the furnace, the draught, and the feed of dust, so as to produce perfect combustion of all the fine particles before they fall to the bottom. The combustion of the smaller particles is not to limited to that of thirty per cent. of the weight of the coal in the mines. There are cases in which the flaming combustion attainable by mixing air through the fuel, instead of merely bringing it in contact with the surfaces of lumps, will save room in furnaces, and thus be of great advantage. In steam boiler furnaces, where the grate-room is heated, it may be advantageous. We think inventors may find piles of money in the piles of coal-dust that need to be catted off.—American Artisan.

Competition.—The authorities of the town of Charleroi, Belgium, invite foreign as well as Belgian architects to submit plans for the enlargement of the town, the demolition of its fortifications, and the re-arrangement of its streets. The first premium is £500; it is not stated whether the successful competitor will be entrusted to carry out his design; the second premium is £300. The premied plans to remain the property of the municipality, which, moreover, reserves to itself the right of purchasing any of the others for the sum of £20.
SMITH'S SELF-ADJUSTING ELASTIC RAILWAY WHEEL.

The defects of most railway wheels now in use, arise partly from their being fixed to the axles resulting in loss of power in traction, by the unequal wear and tear of the tyres, skidding, oscillation of the train, unequal shrinkage of the tyres, and these disadvantages are increased, should the frames of the engines or carriages get out of the square by twisting or straining, leaving out of the question bad road, unequal lengths of the rails at the curves, the harsh and grating sound while passing over the bridges, as well as the enlargement of the engine tyres, when they have to be taken off and reset, all of which have to be taken into consideration.

The object of Smith's Railway Wheel is to obviate the disadvantage of the fixed wheels now in use.

The novelty consists in the body, spokes, or disc-plates being suspended in the tyres. By such an arrangement, the tyres are in compression, while the body, spokes, or disc-plates are in tension, the reverse of the principle now adopted. The advantages, as stated by the patentee, are cheapness, lightness, durability, greater safety to the trains, especially at high speeds, as the tyres cannot separate or break from the body, spokes, or disc plates of the wheels, nor can they mount the rails; the jolting is less, and also the wear and tear to engines, carriages, and permanent way; no skidding, or sliding, or lateral concusion, nor any necessity for double rails at sharp curves, as the tyres regulate themselves; neither is the vibration of the bridges so harsh, on account of the elasticity of the wheels.

The construction of this wheel will be understood from the accompanying diagrams.—Fig. 1 is an elevation of the upper half of a suspended wheel with the disc plate C removed. In this case the tyre D is grooved and the edges or flanges of the disc plates C, C, are turned inwards and inserted in the groove of the tyre, such grooves being of sufficient depth to allow of easy play, with elasticity of action and means of adjustment to the tyre: Fig. 2 is an elevation of the lower half of the same wheel; and Fig. 3 is a transverse section of the whole wheel. When the wheels are fixed to the axles, the tyres must be worn unequally, and there is great oscillation should the frames of the carriages be out of square. To avoid this inconvenience, hollow axles are keyed into the bosses or naves of the wheels, and the solid axles pass through these. The bearings, which may be of any kind, rest on the hollow axles. A spring may be inserted at the back of the boss or nave, being confined by a plate, so as to allow the wheels to yield laterally, and lessen the effect of concussion in that direction. To keep the wheels in their places, and, at the same time, to allow of self-adjustment when travelling over curves or defective roads, plates are bolted to the backs of the bosses, naves, or collars. The wheel is formed separately, and connected to the back of the tyre, which is grooved, by means of either disc or ring plates, rivetted or bolted to the spokes or arms of the boss or nave, and having turned-in edges or flanges, which are inserted in the grooves of the tyre, and are of sufficient depth to allow of easy play, and to afford elasticity of action, and means of adjusting to the tyre.

A set of these wheels have been in use for some time past on the North London Railway, and it is stated that they have given satisfaction. Another set will shortly be employed upon the Great Western Railway, to test their capabilities.

The inventor and patentee is Mr. George Smith, Jun., M. Inst., C.E.
BRILL'S BATHS, BRIGHTON;—VIEW OF EXTERIOR FROM EAST STREET.
BRILL'S BATHS, BRIGHTON: — INTERIOR OF SWIMMING BATH.
BRILL'S BATHS, BRIGHTON.

(With Engravings.)

This building, of which we give exterior and interior views, is now in course of erection on the site of the structure so well known as Brill's Brighton Baths, and will form an important addition to the architectural features of the town. The new building will greatly exceed the former in size, and in the completeness of its arrangements.

The general arrangements consist of a plunging bath on ground floor 52 feet long by 30 feet wide, the ends being semi-circular, and the interior paved with white glazed tiles, on a Portland cement ground. There are eighteen dressing-rooms on this floor, the divisions between which are of light iron enamelled plate. Their doors are of iron, and the passage, being white enamelled slate, on which the floors, too, are constructed. The doors of communication between passage and dressing-rooms, and from dressing-rooms to plunging bath, have glass in the upper panels. The whole of the work is stained and varnished. All the walls on this floor not faced with brick will be in parian cement, tinted to agree with the light green divisions. The whole of caps, string, and cornice are of Devon limestone. The columns are of granite. Hood moulds to arches, Portland stone. There will be an encaustic-tile band under cornice, and two between the first and ground floors. The brick facing is the Bath stone, pointed in fine mortar. The arches are of Suffolk bricks. The whole of the brickwork is of stock bricks in cement. The first floor is furnished with twelve white porcelain baths. This floor is also of slate, and has a space of 2 feet, for pipes, between it and the ceiling below. The roof is of iron, and filled with red and yellow bricks; the interior woodwork will be faced with oak mouldings, and the exterior will be covered with plain tiles. The lantern over is of wood, and the roof of glass. The Pool and Valley front is faced with Bath stone and red Suffolk bricks. The caps, cornice, and strings are of Portland stone; there is an encaustic-tile band between the caps of piers.

The architect is Mr. Geo. Gilbert Scott, A.R.A., and Messrs. Jackson and Shaw, of London, are the builders.

ON RIVETED JOINTS.

By Thomas Baldwin.

Ask a boiler-maker why he places the rivets in a boiler 2 in. apart, and he answers, because "it's the practice," that is because it is customary to do so.

Ask the inspector of a boiler manufacturer the same question, and he tells you, "with his extensive experience and close observation of many hundreds of boilers"—tells you that 2 in. is the best distance, since the boiler-makers use it, and, further, if the rivets are placed at a greater distance apart, the joints cannot be made tight, and, if placed nearer together the metal left between the rivet holes will be too weak to bear the strain upon it.

If, then, you say to these gentlemen it has been found by experiment that a bar of iron 1 in. square used as a rivet will be sheared across by a force of 50,000 lb., and that a piece of boiler plate having a section equal to 1 square inch will be torn asunder by 51,000 lb., and that you conclude from these experimental facts that the area of the rivets and the area of the cross section of the metal left between the rivet holes should be nearly equal to make the strongest boiler, you are at once told that "in theory it may be so, but it has been found that the plates are so much weakened by the use of the punch that nothing short of 2 in. will do for the pitch of the rivets." If you ask to be referred to experimental data showing that this pitch under all circumstances is the best, you are simply told that experience teaches it. This is the law, and the user of this article must go to the best method of construction.

The writer, is, therefore, desirous of placing this matter fairly before those who spend large sums of money on steam boilers, and yet get only 75 per cent. of the strength that correct principles of construction will give, and, therefore, pay 25 per cent. more for a boiler than is required. If the principles of construction be attended to, or get a boiler that is 25 per cent. weaker than it ought to be. However strange it may seem, a boiler made of 2 in. plates and put together with 4 in. rivets and 2 in. pitch, is just as strong as a boiler made of 3 in. plates, with the rivets and pitch the same as used for the 2 in. plates, for both would give way, by the rivets being sheared across, which causes the user of a boiler to pay 25 per cent. more for his boiler than he ought to pay.

We will now try to ascertain and confirm by mathematical demonstration what ought to be the proper pitch to get the strongest riveted joints for steam boilers from the least material when the thickness of plates and the diameter of the rivets are given.

As mathematical demonstration is by far the shortest and simplest way of arriving at the required result,

Let \( P \) = pitch of the rivets in inches.
\( d \) = diameter of the rivets in inches.
\( a \) = area of one rivet in inches.
\( t \) = thickness of plates in inches.
\( s \) = number of pounds required to shear one square inch of wrought iron in the form of rivets.
\( p \) = number of pounds required to tear asunder one square inch of the boiler plate, left between the rivet holes after punching.

Then the sectional area of the plate between any two rivet holes is
\[
\frac{P}{(P-d)t} \cdot \frac{a}{s} = \frac{P}{(P-d)t} = \frac{a}{s}
\]

and the force required to tear that section asunder is
\[
\frac{P}{(P-d)t} = \frac{a}{s}
\]
The force required to shear one rivet across is
\[
\frac{P}{(P-d)t} = \frac{a}{s}
\]

Now, to economise material, and make the strongest single riveted joint, we must make the rivets just on the point of shearing across when the plates are just on the point of being torn asunder; thus (1) and (2) must be equal, or
\[
\frac{P}{(P-d)t} = \frac{a}{s}
\]
from which we get
\[
P = \frac{as}{t} + d
\]

and
\[
\frac{P}{(P-d)t} = \frac{a}{s}
\]

Now Mr. Fairbairn has given a table for practical use, in which the thickness of the plates, the diameter of the rivets, and the pitch of the rivets are stated.

Making \( s = 50,000 \) lb., which has been arrived at by experiment, and given on the authority of Professor Rankine, and making \( P, d, \) and \( t \) agreeable to Mr. Fairbairn's table, we find by equation (5) the values of \( a \) in table 1, column 5:

<table>
<thead>
<tr>
<th>Plate</th>
<th>Rivet d</th>
<th>Pitch P</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>375</td>
<td>1-25</td>
<td>11044</td>
<td>33670</td>
</tr>
<tr>
<td>500</td>
<td>1-50</td>
<td>19835</td>
<td>32970</td>
</tr>
<tr>
<td>626</td>
<td>1-625</td>
<td>30926</td>
<td>46088</td>
</tr>
<tr>
<td>75</td>
<td>1-75</td>
<td>4417</td>
<td>58933</td>
</tr>
<tr>
<td>8125</td>
<td>2-30</td>
<td>5349</td>
<td>43386</td>
</tr>
<tr>
<td>9375</td>
<td>2-60</td>
<td>6993</td>
<td>35346</td>
</tr>
<tr>
<td>1-125</td>
<td>3-00</td>
<td>994</td>
<td>35343</td>
</tr>
</tbody>
</table>

The values of \( a \), shown in the last column, are very variable indeed, attaining a maximum in the case of 3 in. plates amounting to 58,693 lb., while the experiments made by Mr. Fairbairn on the tensile strength of boiler plates, and given in his paper read before the Society of Arts in November, 1864, gives the mean value of \( a = 52,486 \) lb., and yet we find the values of \( a \) as deduced for 3 in. plates from Mr. Fairbairn's table, amounting only to 43,669 lb., and for 4 in. plates as low as 39,570 lb., a discrepancy quite unaccountable.

The common practice of making the distance between the rivets 2 in. for 4 in. plates with 3 in. rivets, given by equation (5) the value \( a = 51,041 \) lb., which is a close approximation to the strongest form of joint for single-riveted plates.

If \( a \) be taken of the same value as Mr. Fairbairn recommends for 4 in. plates, we have by equation (4)
\[
P = \frac{as}{t} + d = \frac{4417 \times 50000}{5 \times 68893} + 75 = 1-5\text{ in. (A)}
\]

* Read before the Society of Engineers.
But if the pitch of the rivets for $\frac{1}{2}$ in. plates be 2 in., then $n = 51,041$ lb., with $\frac{1}{2}$ in. rivets and $\frac{1}{2}$ in. plates we get:

\[ P = \frac{4417 \times 50000}{\cdot5 \times 51041} + \cdot75 = 1\cdot615 \text{ in.} \quad (B) \]

Mr. Fairbairn gives a number of experiments on single-riveted joints in the "Philosophical Transactions for the year 1850," and in his "Useful Information for Engineers," the thickness of the plates used being $\frac{1}{2}$ in. and 3 in. broad, put together with $\frac{1}{2}$ in. rivets.

The mean breaking weight of all the experiments is given at 18,360 lb.

The area of the two rivets being $2 \times 19685 = 3937$, and the sectional area of the plates after punching is $(3 - 1) \cdot22 = \cdot44$, from which we get:

\[ n = \frac{18590}{\cdot44} = 42250 \text{ lb.} \quad (C) \]

which being used for $\frac{1}{2}$ in. plates with $\frac{1}{2}$ in. rivets, we have by (4)

\[ P = \frac{4417 \times 51000}{\cdot5 \times 42250} + \cdot75 = 1\cdot795 \text{ in.} \quad (D) \]

Mr. Fairbairn's experiments with plates $\frac{1}{2}$ in. thick, $\frac{1}{2}$ in. broad, fastened together with three rivets $\frac{1}{2}$ in. in diameter, gives:

Area of the three rivets $\ldots \ldots \ldots \ldots = 589 \text{ in.}$

Area of plates, deducting rivet holes $= \cdot44 \text{ in.}$, which broke through the line of rivets by 19,675 lb., giving

\[ n = \frac{19675}{\cdot44} = 44534 \text{ lb.} \]

Had these plates been 4 in. broad, instead of 3 in., the section of the plate after punching would have been 2,675 $\times \cdot22 = 589$, equal to the area of the three rivets, and the riveted joint much stronger, the ratio of strength being nearly as 100 to 84.

But experiments made on only two or three rivets is no fair criterion, as Mr. Fairbairn has suggested, for he concludes that the strength of a single-riveted joint, including the rivet holes in the measurement of the section of the plate, is fairly represented by a breaking strain of 34,000 lb. on the square inch of such section.

Now, the entire section of the plate used in the experimental inquiry with two rivets, was $3 \times 22 = 66 \text{ in.}$, and the section of the plate, after deducting the rivet holes, will be $(3 - 1) \cdot22 = \cdot44 \text{ in.}$; we then have $n = \frac{3400 \times \cdot66}{\cdot44} = 51000 \text{ lb.}$ as the power of the riveted plates to resist a tensile strain.

Applying this value of $n$ as before, we find for $\frac{1}{2}$ in. plates and $\frac{1}{2}$ in. rivets:

\[ P = \frac{4417 \times 50000}{\cdot5 \times 51000} + \cdot75 = 1\cdot616 \quad (E) \]

The mean of these results for $\frac{1}{2}$ in. plates will be found to give $P = 1\cdot63 \text{ in.}$

We therefore find that the shearing force and the tensile force are so nearly equal that for practical purposes they may be considered so; we can then dispense with $\alpha$ and in equation (4), which becomes

\[ P = \frac{\alpha d}{\sqrt{\frac{\pi}{2}}} + \cdot75 \quad (F) \]

which gives for $\frac{1}{2}$ in. plates and $\frac{1}{2}$ in. rivets

\[ P = \frac{4417}{\cdot5} + \cdot75 = 1\cdot6334 \text{ in.} \quad (G) \]

nearly the same value as the mean of all the other deductions.

After Mr. Fairbairn has analysed his experiments, he says:—"If we take the mean of the experiments as respects the area of the rivets to that of the plates, we find one-half in rivets about the proportion, or the area of the rivets in the last experiments should have been $\frac{1}{2}$ in., which is nearly equal to the area of the plates through the rivet holes."

The following note is also attached:—"Subsequent experiments made for ascertaining the strength of rivets (made on rivets for the Britannia and Conway tubular bridges) fully corroborate these views, namely that riveted joints exposed to a tensile strain are directly, or nearly so, as their respective areas, or, in other words, the collective areas of the rivets are equal to the sectional area of the plate taken through the line of rivets."

Again, in his paper read before the Society of Arts (November, 1884), he says:—"In this estimate we must however, take into consideration the circumstances under which the results were obtained, as only two or three rivets came within the reach of experiment; and, again, looking at the increase of strength which might be gained by having a greater number of rivets in combination, and the adhesion of the two surfaces in contact, which in the rivet-joints compressed by machine is considerable, we may fairly assume the following relative strengths as the value of plates with their riveted joints:

Taking the strength of the plate at $\ldots \ldots \ldots \ldots = 100$

The strength of the single riveted joint will be $\cdot55$."

Now we find, by equation (6), for all practical purposes, $\alpha$ and $\pi$ are so nearly equal that they may be neglected, and that

\[ P = \frac{d}{\cdot7} \quad (7) \]

Then we have 100 : 56 : : $P$ : $d$. But it has been shown that the area ($\alpha$) of the rivet must enter into the calculation, and if we substitute the equivalent of $P$ from (7) we get:

100 : 56 : : $P$ : $\frac{d}{\cdot7} \quad (8)$

which for $\frac{1}{2}$ in. plates and $\frac{1}{2}$ in. rivets gives:

\[ P = \frac{1\cdot7857}{\cdot7} = 1\cdot774 \text{ in.} \quad (F) \]

Or substituting the value $7854 \; d \cdot 4$ for $\alpha$ in (8), we have:

\[ P = \frac{1\cdot4d^\cdot4}{\cdot7} \quad (9) \]

This expression for the distance of the rivets is therefore deduced from Mr. Fairbairn's estimate of the whole of his experiments, and gives values differing from Mr. Fairbairn's table, given in his paper, and before quoted.

Now Mr. Fairbairn gives distances for rivets which, he states, he finds the best in practice, yet at the same time they do not agree with his deductions from experiments.

No one will doubt the importance of having the shells of boilers made of the strongest possible construction.

When the single-riveted joint is used, and the thickness of the plates and diameter of rivets given, we have seen that the true pitch of the rivets is given sufficiently near for practical purposes by equation (6), and also again as deduced from Mr. Fairbairn's estimate of his own experiments by equation (9).

A table, giving the pitch and diameter of the rivets, and the thickness of plates, will be found below, containing the results of both these investigations.

<table>
<thead>
<tr>
<th>Thickness of the plates in inches</th>
<th>Diameter of the rivets in inches</th>
<th>Area of the rivets in inches</th>
<th>Pitch of the rivets in inches. Equation (6)</th>
<th>Pitch of the rivets in inches. Equation (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{2}$</td>
<td>25</td>
<td>5</td>
<td>$\frac{\pi a}{\sqrt{\frac{\pi}{2}}} + d$</td>
<td>$1\cdot4d^\cdot4$</td>
</tr>
<tr>
<td>$\frac{3}{4}$</td>
<td>21</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>19</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>17</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>15</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>13</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>11</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>9</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>7</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The fourth column of the last table seems to be entirely trustworthy as to the pitch of the rivets, since the relations of the strains are more uniform than would be the case if the formula of the last column was used. Where the holes are punched their mean diameter should be taken in fixing the pitch, as the taper of the hole, reduces the area of the metal between the rivet holes, and it is only necessary to increase the pitch by the amount the mean diameter exceeds the diameter of the punch.
As double-riveted joints are made up of two parallel rows of rivets, we have to determine first the distance from centre to centre of rivets measured along the rows, and secondly, the distance between the centres of the two parallel rows of rivets.

Mr. Fairbairn gives the pitch or distance between the centres of the rivets for double-riveted joints the same as for single-riveted joints, but that distance, the writer presumes, is measured diagonally from one row of rivets to the other, so as to form two rivets in one row and one in the other into an isosceles triangle, and the distance apart of the two rows of rivets can only be determined by knowing that the lap for double-riveted joints is to be one and three-quarter times the lap of a single-riveted joint, and placing the two rows of rivets at the same distance from the edge of the plate as for single-riveted joints.

Now, if we place the two rows of rivets that they shall form a number of isosceles triangles, they will, when measured diagonally, and having equal distances apart, have the following values.

Make \( P \) equal the pitch of the rivets in each row as before, and \( D \) the distance they are apart, measured diagonally, and \( D \) the distance between the two rows of rivets; and all the other values the same as before, then

\[
(P - d) t
\]

represents the sectional area of the plate between the rivet holes in each row of rivets, and

\[
(P - d) \sin \theta
\]

the force required to tear that section asunder.

The rivets are to be sheared across by the force that would tear the last-named section asunder are two in number, and this force is represented by

\[
2 as
\]

and as before, in the case of single-riveted joints, the values indicated by (10) and (11) must be equal, that is,

\[
(P - d) \sin \theta = 2 as
\]

But it has since been shown before that \( s \) and \( n \) are equal; hence

\[
P = \frac{2a}{\sin \theta} + d
\]

the distance the rivets ought to be apart to ensure the strongest and most economical structure.

The sectional area of the plates between the rivet holes, taken diagonally, according to the principles of stress, need not be greater than half that of the plate between the rivets of each row; that is,

\[
D - d = \frac{P - d}{3}
\]

Therefore,

\[
D = \frac{P + d}{2}
\]

and by substituting the value of \( P \) from (13) into that of (14) we get:

\[
D = \frac{a}{\sin \theta} + d
\]

If we make the distance between the two rows of rivets one half the distance of the pitch of the rivets measured longitudinally, we shall get \( D \) rather in excess of the above value (15), and approximate very closely to the experimental form with double-riveted joint made by Mr. Fairbairn.

The Table I. applies equally to double and single-riveted joints, since Mr. Fairbairn gives the pitch of the rivets the same for one as the other, although it is difficult to see why, since the strength of the double-riveted joint depends entirely on the proper proportion of the pitch of the rivets in each row to the diameter of the rivets and the thickness of the plates, and not on the distance between the two rows of rivets, or the diagonal distance of those rivets, so long as the last two distances are not so small as to cause the plates to be torn or asunder diagonally. Any excess above these distances only adds to the cost and weight of the structure, without increasing its efficiency.

In Table II. the fourth column gives the pitch of the rivets for double-riveted joints, and by comparing equation (6) from which that column is computed, with equation (13) for double-riveted joints, we find that it is only necessary to add \( \frac{a}{\sin \theta} \) to the values of \( P \) in the table, in order to obtain the correct pitch of the rivets for double-riveted joints.

Taking experiments Nos. 38 and 39, Table X. of Mr. Fairbairn's experiments on double-riveting, as the most conclusive, we find that the thickness of the plates are \( 22 \), the diameter of the rivets three-eighths \( = 0.375 \), the breadth of the plates \( 3 \) ft. 12 in., the mean breaking weight 23,707 lb., fracture taking place across the rivet holes A, B.

In these experiments there are five rivets to shear across, and the sectional area of the plate, deducting the rivet holes across A, B, should equal the area of the five rivets, that is,

\[
1104s \times 5 = 5522
\]

and \( 5529 + 29 + 3d = \text{the width of the plate to be of the strongest form}, \ d \) being the diameter of the rivets, from which we get 3 ft. 63 in. as the width of the plate, whereas the experimental plate was only 3 ft. 12 in.

Now, to have been in accordance with double-riveted joints as used in practice, the experiment should have been on six or any other even number of rivets, if the object be to determine the distance or pitch of the rivets. As an example, take the shell of a steam boiler, the direction of the rivets passing round the shells is shown at \( a \) and \( b \), and the double or longitudinal rivets at \( c \) and \( d \). The distance of the rivets in each row of the double-riveted joint will then be given by the equation (13) as before stated.

Circular steam boilers with two flues, the strain on the riveted joints is very variable, for whilst the joints that run parallel to the axis of the shell have a strain upon them of three units, the joints that pass around the circumference of the shell have only a strain of one unit upon them; hence this class of boilers should have the longitudinal joints double, riveted, and the other single riveted, when, owing to the ring of rivets passing round the boiler on each edge of every set of plates, and the double-riveted longitudinal joints, the boiler would be as strong with this combination as if the whole were made of solid rings of plates, providing the plates are not made too wide.

The common practice of boiler makers in Lancashire and Yorkshire is to use two inch pitch and three-quarter rivets, whether the plates be three-eighths, seven-sixteenths, or one-half inch, which cannot be too much condemned; yet we find chief-engineers of boiler associations stating that this is the correct method of constructing steam boiler riveted joints, although experiments decide to the contrary.

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The Architectural Association.

This Society commenced its 26th session on the 26th ult., under the Presidency of Mr. Robert W. Edis, A.R.I.B.A., who also filled the Presidential chair during last year. The meeting was numerously attended, a conversazione forming a part of the evening's engagements, but the principal business of the evening was the delivery of the President's valuable inaugural address, which will be found reported in another part of this month's number of this Journal.

We are glad to draw attention to the very excellent syllabus of papers to be read during the Session 1866-7, which the Council has been enabled to issue, containing as it does, many subjects of the greatest practical value to the architectural student, and which will be treated by men, several of whom have long been well known for their distinguished attainments in connection with architectural art.

The committee express their great satisfaction in observing the continued increase in the number of members of the Society, which affords proof of its utility, and supplies the means of increased usefulness. The list of members now numbers 333, against 280 and 246 in the last and preceding years respectively.

The number of architects in practice who belong to the association and take part in its business is considerable, but the members generally are students, and it is from this class chiefly that new members are expected to be obtained. For their information, therefore, the committee set forth some of the advantages of membership, and express their wish for a still larger addition of that class for whose benefit the association was founded and now exists. The ordinary meetings of members are held on alternate Friday evenings, when papers upon architectural questions are read. In the discussions which follow, all members are encouraged to join, and it is to be desired that
this favourable opportunity of acquiring the power of public speaking were more generally used.

The Vice-Presidents are Messrs. E. Phene Spiers, and Edward J. Tarver, and the Committee for the session now commencing are Messrs. G. H. Birch; J. S. Edgerton; E. R. Perry; H. L. Florence; E. Lee; C. H. F. Lewis; W. Longdale; J. T. Perry; L. C. Riddett; and L. W. Ridge; Hon. Treasurer, Mr. J. D. Mathews; Hon. Secretaries, Messrs. J. D. Mathews and Rowland Plume.

Students of architecture in the metropolis would do well to avail themselves of the opportunities for improvement which are placed within their reach by this Society, which has proved of great benefit to those who have become members.

NEUMEYER'S NEW POWDER FOR GUNS AND BLASTING.

The new powder discovered by Herr G. A. Neumeyer, a manager of stone quarries at Taucha, near Leipzig, is said (Berg- und hüttentümnische Zeitung, No 38, 1866, p. 309) to possess the following properties:

1. The powder burns, but does not explode if the air has access.

To prove this the following experiments were made last year at Altenburg, in the presence of the Town Council:

(a.) An earthenware drain pipe, about 11 inches long and 4½ inches internal diameter, was placed upon a brick and buried in the ground for two-thirds of its length; it was then filled with about 4½ lbs. of Neumeyer's powder, and this lighted. The powder burnt quietly, merely setting up a long flame. Later the experiment the drain pipe was found to be quite uninjured.

(b.) A conical earthenware tube, 16½ inches high and 4½ inches in diameter at the bottom, and rather more than 1 inch at the top, was buried in the ground for two-thirds of its height, and filled up to the mouth with about 1 lb. 8 oz. of Neumeyer's powder. On being lighted, the powder burnt somewhat quicker than in experiment (a), but the vessel was uninjured.

(c.) An earthenware bottle, with a large body and very small neck, was filled with 1 lb. 10 oz. of Neumeyer's powder. It burns very quickly, giving a long flame; the upper part of the vessel broke off in consequence of the great heat, and fell down by the lower part.

As counterproof, a similar but smaller vessel was filled with about 9 oz. of ordinary powder; it exploded with a loud report, and the vessel was broken into numberless fragments, which were scattered about for a great distance.

(d.) A very instructive experiment was performed with an iron gun-barrel 3 feet long and 4 inch in diameter. The barrel was filled up to the muzzle with Neumeyer's powder, and this was lighted through the touch-hole. The powder burnt, sending out a curved flame through the touch-hole, and it was only the last portions that were projected in a small flame from the muzzle.

On the 27th November, 1865, the following experiment was made in a quarry at Taucha, and shortly afterwards it was repeated before a large assembly at Altenburg. A small house was built, 4 feet 8 inches high, 2 feet 6 inches long, and 2 feet 6 inches deep, with walls 6½ inches thick. In front an opening for a door was left, 11 inches square, and at each gable end there was a window 24 inches square, closed with thin boards. A powder of 33 lbs. of Neumeyer's powder was put in through the opening for the door, which was then closed with a piece of sheet iron. The powder was ignited by a fuse; it burnt without making any impression on the house, and even the wooden box retained its shape, being merely charred. To show the contrast with ordinary gunpowder, a pound of this, loose, as in the mortar, was put in the little house. On its being ignited, the house was shattered into pieces.

2. Neither pressure nor concussion will cause it to ignite.

3. Its explosive force is equal to that of ordinary powder or even greater.

4. It leaves behind no residue than ordinary powder.

5. It does not attract more moisture from the atmosphere than ordinary powder.

6. It leaves behind less powder-smoke than ordinary powder.

Its smoke, however, is light, disappears quickly, and has no injurious effect on the health of the workmen.

7. It is cheaper than ordinary powder in the proportion of 30 to 81. The prices by weight are the same, but as it has been found that 7½ grams of Neumeyer's have the same explosive force as 7½ grams of ordinary powder, the above proportion may easily be deduced.

It appears that Neumeyer's powder is as strong as ordinary gunpowder in spaces that are made as far as possible air-tight, but that when the air has access it burns without exploding. Herr W. Kretzer, inspector of mines in the Duchy of Saxe-Altenburg, adds the following concluding words to Herr Neumeyer's pamphlet:—I must really call Herr Neumeyer's discovery a blessing for mankind when I look at the frightful accidents caused by explosions, which recur year after year in all quarters of the globe. I need only recall the great explosions at Magdeburg, the disaster in 1865 recently lately in the laboratory of M. Aubin in Paris. All imaginable precautions, the strictest regulations, and the most expensive arrangements for transport and storing, do not strengthen the thread by which the life of those who have to do with gunpowder must always hang. How many soldiers are killed in battle when an ammunition wagon explodes, and how much greater is the disaster when the powder magazine explodes on board a man-of-war! All these disasters in war and in peace will be avoided by the use of Neumeyer's powder. Accidentally ignited, it will burn out quietly, whether in a massive tower, in ammunition wagons, or on a board ship, but will not explode. It will at most lift up the rafters which should be fixed to the cases, and probably will not cause the fire to extend to other combustible materials, for I expect it will have a similar effect to Boucher's fire extinguishers. Just as the spectators stood only five paces from the little house when 33 lbs. were burning, so one will be in perfect safety at a short distance when several tons are lighted.'

ARCHITECTURAL ASSOCIATION.—OPENING ADDRESS SESSION 1866-67.


Another year has brought us again together, and once more I have the honour of coming before you, as your President, to address you at the commencement of the new session. When I addressed you last year, I did not expect so soon again to have the pleasure of doing you the honour of re-election as your President, it is, at the same time, a source of much gratification to me, as a proof of your esteem and approval during my last year of office.

In starting upon our twenty-fifth year, I must again congratulate this Association upon its continued and increased success. I believe that each and every one has been making a useful to each other, and gaining increased influence abroad, and I think there can be no doubt that, if properly managed, our Association should become one of the most important societies of the kind in London; for, remember, we clash with none; we hold with all proper respect the Royal Institute, of which very many of us are members; but we have belonging to us a variety of essentially useful classes, which, I believe, peculiar to our society, and I cannot attach too much importance to their usefulness, for, without doubt, they encourage and foster a spirit of work and friendly competition, give room for the interchange of friendly opinions, and are the means to many of us of forming acquaintances which, depend upon it, we shall none of us regret in afterlife; for, as I have always urged, the more young architects know of each other, and the more they work together in unity, especially in those things pertaining to their art, the better it will be for them, and the more pleasant will be their after business intercourse; and remember, too, that the Architectural Association, as the younger society, becomes the nucleus of what must needs be the future generation of architects. I can only hope that our members will yearly increase, as they have done during the last few years, our numbers being now nearly 360, for I believe, in these days of societies, unions, and amalgamations, the more work as a body cling together, the stronger and the more able shall we be to assert our own, and to
November 1, 1868

THE CIVIL ENGINEER AND ARCHITECT’S JOURNAL.

raise the profession to which we have the privilege of belonging. Our funds are in a prosperous state, and the attendances at the usual fortnightly meetings, as well as at the various classes and lectures, are as large as they have been for a long time past. The demand for the office of the society has been much in excess of the supply, and the committee of management has therefore not had much difficulty in disposing of the subscriptions of those who have applied for membership. The number of subscribers is now over one hundred, and the society is consequently in a flourishing condition.

With regard to the classes of design, we have had many applications, and have been able to accommodate ourselves to the demand. The classes have been well attended, and the results of the examinations have been satisfactory. The judges have been unanimous in their reports, and the committee of management have been pleased with the conduct of the classes. The society has also been able to make a fair return for the subscriptions of its members, and has been able to keep up a steady and increasing attendance.

As regards the exhibitions and competitions, we are able to say that the society has been able to make a fair return for the subscriptions of its members, and has been able to keep up a steady and increasing attendance. The society has also been able to make a fair return for the subscriptions of its members, and has been able to keep up a steady and increasing attendance.
young man, M. Garnier, and that his design had both times been voted the best; and it is moreover worthy of notice, as an instance of the highest superintendence of a French Saint-Paul, that however, much we may regret that it should be based on foreign learning, never fails to impress the minds of each and all with admiration at its charming unity and magnificent proportion; and the man who, while confessedly working out in all his works the principles of Roman and Greek architecture, has left us not the better but worse, and Green Howards, besides the host of churches scattered everywhere in this great city, was no common man, and to him in a measure we owe the fashion of pillars and columns, vast porticos, and domes.

Then came Vanburgh, Gibbs, Kent, Burlington, Stewart, and Chambers, all more or less following the footsteps of Jones and Wren, but none of them. Then that wonderful age of mawkish uncertainty, and Batley Langley Gothic, that age of plainness and ugliness, which Gower-street, Wimpole-street, and other streets so well exemplify; until last came in a grand revival upon this, and gaudiness and vulgarity, in the shape of hosts of plastered abominations, recce ornaments, and sham enrichments, succeeded upon what was at least, if plain, unobtrusive; and in our day and generation we have to look upon street after street of plaster commonplace, and line after line of sham cornices and sham decoration, until our city has become a city of sham and unreality, a city that one year seems prema-
turely. Shall it be so for ever? One line of morning into all the glory of triennial whitewash, and shams for a time in borrowed plumes and unreal misery.

Briefly such has been the history of architecture for the last two centuries and a half, and gradually this learned pedantry, puny in its very absurdity, insomuch as it has sought to teach us that the art of the Romans was to be the art of a nation whose views, thoughts, and feelings, independent of the lapse of some 14 or 15 centuries, were totally different; and although no one can deny the great genius of the masters, such as Scamozzi, Jones, Wren, and Chambers, who have left noble and magnificent works behind them, yet it would be insulting to all to assert that the age which has given to London the miserable monotony and boldness of Gower-street and Harley-street, or the pale unreality and commonplace of Belgravia, Pimlico, and Bayswater, and on the continent has been the father of such feeble monstrosities as the Rue de Rivoli, and has in so many places substituted all that is vulgar, unreal, and frivolous, true and genuine ancient grandeur and feebleness of successive rows of pilasters, square holes, and bracketed cornices, for the clustered doorway and traceried window, is sought but a vain and foolish pedantry, chimera-like in its very failings, and hideous in its very monotony of design, if design it be at all. Classic, Italian, Renaissance, Palladian, or whatever little you will call it, but the bad and bad copy of a copied architecture, and can have no hold upon our hearts, and leaves us with nothing but the flimsy spectres of others' works, and to muse why that fair and lovely work of our forefathers should be forsaken; knowing as we do, that we have now only to follow it up, and with greater means and more appliances to adapt it; as it may be adapted either for the town or the country, for the cottage equally with the church, for the factory equally with the mansion; for man's requirements have varied but little, and are amongst the things that have been and will be again.

But in the midst of all the regalia for the beauty that has been professed, there is one thing to despise, as if the fountains of beauty were reserved in heaven, and flow not more to us on earth; no need to be always looking back till our heads are well nigh twisted off our shoulders; why all our reverence, all our faith, for the past, as if the night were already come, in which no man can work, nor there were not more for us to do in the cause of humanity, for progress in the cause of good? But there has been, and is still much shaking amongst the bones, and our nineteenth century may yet retrieve itself, and leave at its fall something for future generations to be proud of. Notably amongst house architecture are the new buildings now being erected in Pimlico and Belgravia, on the Marquis of Westminster's estate, especially their good honest stone and colored brick, and terra cotta decoration, are a vast improvement on the buildings they have replaced. Then again, wander through the city wherever you will, and you will everywhere see good buildings of all kinds gradually taking the place of the old commonplace structures that have succeeded them. Amongst these
November 1, 1868

THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

are the new auction mart, and the Venetian Gothic buildings adjoining the same, both by the same architect; Messrs. Cunlliff &
and other new banks in Lombard street, the immense piles of
offices not far from the City Churches; and innumerable warehouses
sprunging up in all directions, most of
them at least worthy of attention for some individuality and
improvement in architectural design. One more especially,
that lately erected by Mr. Burges, in Lower Thames-street, I
would name, as exemplifying how much can be done, at a small
expense, in small towns, and especially in the streets of the
city, and how better being made by the Board of Works are opening up or destroying
much that was old and ugly, and already in one of these is
rising up large and magnificent buildings that bid fair to make it
one of the finest streets in London. Whether it would be
better for us if we were tied down in a smaller, like our neigh-
bours across the channel, to a certain uniformity of design in our
new streets and public places, is a question that has more
sides than one. Certainly I think we must admit that the
magnificence of some of the modern boulevards and streets in Paris,
and other large towns on the continent, is much enhanced by the
compensating sense of grand and uniformity of the buildings, which
perhaps, be somewhat monotonous, but which never lack, in my
opinion, either refinement or grace in much of their design and
proportion, and which will go to France of our day and time
an individuality in its architecture, which, I fear, we shall not,
or, at events, have not yet attained to.

Then speaks the Idea of the Consort's Memorial in Hyde
Park, the new Foreign and India offices, now fast
approaching completion, the new theatre in Holborn, and many
other public and private buildings too numerous to mention
here. Whether in these great days of public companies, and
public smashings, we are always to be liable to such hidden sights
as that which is presented by the completion of the concentric
never finished Strand Hotel, or the hideous monstrosity of
Leicester-square, is a question I suppose that time only will
answer. One work especially we shall some day be proud of, I
mean the Thames Embankment, and those who live to see it
and its accessories completed, will see the realization of one of the
most important conceptions of modern times.

It is somewhat curious to find that Wren, than whom no
more grand conceivest of grand things ever lived, had in his mind
the idea of something of the kind of work that is now going on;
for to quote Allan Cunningham, who says in his life of this great
man, that he had planned a long and broad wharf or quay by the
water side from old London Bridge to the Temple, where
he designed to have arranged all the halls belonging to the
several companies of the city, with proper warehouses for
merchants between, to vary the edifices, and to make it at
"once one of the most beautiful and useful ranges of structure in
the world;" and now, after the lapse of more than 150 years, we are
seeing that the plan and the scheme are being rationally
scaled more grand and more important than Wren could have thought
of, even in his days of greatest royal favour.

I am glad to say that a great stride is being taken in the
improvement of the dwellings for the poor, and thanks to Mr.
Peabody's noble gift, and the indefatigable exertions of such men
as Mr. Alderman Waterlow, Mr. Torrens, Mr. Godwin,
and others, large blocks of buildings are being erected in various
parts of London, replete with every comfort and improvement;
and too much importance cannot be attached to such a step as
this, which, by effecting the external comforts of the poor, by
giving them better and more healthy homes, is likely to remove
more and more of the prevalent evil of public suffering is to be the order of the day, then pray God this
improvement may be entirely effected first. The works of the
Holborn viaduct are proceeding rapidly under the energetic
superintendence of Mr. Heywood, and when this great work
and its attendant improvements are completed, I doubt not
that they will prove of immense convenience to the toiling wayfarers
in this great city.

The new stations and hotels at Charing Cross and Cannon
street are all steps in the right direction, though perhaps a
little less plaster, and a little more reality, might have been good,
and are likely, when completed, to be eminently the
gigantic terminal stations of our city with those of Paris.

The new Freemasons' Hall, in Great Queen street, by
Mr. Cockerell, is certainly one of the most noteworthy of the
buildings of the year, and exemplifies how much can be done by
an educated and refined taste in classic work, without making it
a mere copyism; the symbolic figure carving, and the statuesque
work, which are as good as can be produced, exemplify how much
a new spirit has been infused into our building.

New bridges are spanning the Thames and our streets in all the
glory of their practical straightness. I suppose railway bridges
must be ugly, the lines of wrought and cast iron are probably fallen
on bad places, for certainly lattice girders and cast iron fronts are
not the pleasantest things to look upon, and straight bridges
rustling their feet on high houses, and医疗机构 beside bands of colored iron,
and telegraph posts perched on the top of high roofs, like clothes
props with their attendant lines, are not pleasant features in the
city landscape, and it seems to me that one of the greatest things
that the architects of the present day can do, is to throw into
their works something of the aesthetic and artistic as well as the
practical element, and he who shall have designed a straight
railway bridge with some art taste will have achieved a great art
success, for it is the difficult things of design that call forth
the genius and skill of the designer. May we hope that the day is
yet to come, when useful things shall not be ugly things, and
when even to railway bridges and telegraph posts something
notastic treatment shall be given; and let us hope that,
ere long, our city may cease to be overrun and cut up by mon-
strous incongruities of design, and gigantic monuments of
ugliness, such as many of our great engineering works now are.
But remember, you must have a thorough knowledge of the
designs of those who have gone before you before you shall
be able to understand the faults and beauties of all work, and to appreciate in all styles that
unity and harmony of parts which they essentially possess;
for even as until you thoroughly understand the idioms and
roots of a language you cannot write or speak it well, so must
you study in architecture.

"Twining memories of old time,
With new virtues more sublime;"

for knowledge, not ignorance, must be the foundation of good
work, and there is no better way of obtaining this knowledge than
by continually and perseveringly sketching old work;
steam and rail now-a-days enable you to wander where you
will, and to make short or long holidays as you please in the
midst of all that is beautiful and good in architectural work;
you need not leave our own country to sketch, but sketch,
sketch, everywhere, and continually, and by doing so, you will
acquire a knowledge of the principles that guided the old
architects, and a direct training and culture of the eye to apre-
dicate and understand the grace and beautiful proportion of their
works, and c knowledge of what is right or wrong in architectural
form and outline; always keep a note book in your pocket, and
never lose an opportunity of sketching ancient examples. Be
sure you will find this a pleasant occupation, as well as a useful
one: not to mention the having a collection of interesting
material in which you can work, and, if you choose, can
I can but ask you to look around our walls here to-night, to see
one of the most beautiful and interesting series of sketches
that I have ever beheld, and to take a lesson from them of what
may be done in sketching. Few, if any of us, can hope to excel
in it, as our Vice-President, Mr. Spiers, to whose sketches I
am referring, does, yet we may learn from him and from his
sketches what may be done by talent, perseverance, and hard
work.

In practice you will have to contend with many difficulties, to
soothe and manage perverse and parasitical clients, who
probably are wanting barns when you are dreaming of
stability and order. The architect's work is not a matter of forms and
fashions, will meet you at every step, but you must not give way,
for remember that you are called in to advise as to taste, and of-
times to correct and educate it, in fact; and that you will be
a hundredfold more looked up to and respected afterwards, even
if you are more advance in knowledge, if you shall be able to
shrewdly and thoughtfully form your opinions; and although I wish not here to raise
any battle of the styles, still I would urge upon you to study
well our old English work before you go away from it to follow
in the ways of ancient classic examples, remembering always
that it is endeared to us by the memory of a thousand years, among the others, the mound
with a great variety of domestic examples, from the cottage to
the mansion, all help to show that we are admirable Gods; while,
with a few notable exceptions—St. Paul's, Whitehall,
and Somerset House, to wit—the endless excesses of rococo and
plaster abominations, in all the miserableness of their monstrous
unreality and meaningless vulgarity, help to teach us that we can never become good Greeks or Romans. Study well all works of art you see, but you will never be able to adapt or even to be admirably adapted in either style to the requirements of centuries ago, will no more be suitable in these days than the primitive garb of the Britons, or the fantastic costume of the mediaevalists, for the dress of nineteenth century men and women.

Learn well your art, think no labour too severe, and no knowledge too obscure, but do not forget to study, but also how to adapt ancient examples that you have studied, it should be, as Lord Aberdeen said, 'Not with the timid and servile hand of the copyist, but with a due regard to the changes of customs and manners, to the difference of climate, and the conditions of modern society. It is not the details, or even the form of the edifice itself, however perfect, which ought to influence us, 'But we should rather strive to possess ourselves of the spirit and genius by which the old buildings were originally planned and directed, and to acquire those just principles of taste which are capable of general application.' You will require to have an intimate knowledge of the necessities and requirements of the buildings you design, whether it be for the large and costly mansion, the suburban villa of the city merchant, or the frugal cottage or farm homestead. In the restoration of either ecclesiastical or domestic work, you will find a knowledge of archaeology of much service, and your study of ancient examples most valuable and useful, for your knowledge of the detail of the buildings you design, whether to keep and what to alter, what to avoid and what to restore; and it behoves you to bear in mind that the true and honest lover of his art will seek diligently in all cases to preserve, and not to destroy; to restore the old rather than to make the new; and, when called upon to add to ancient work, I believe that you should have a single idea, and to individualize your own work, and, while so designing it that it shall not seem incongruous with the general building, but harmonize with it in its lines and proportions, yet shall you make it evident and apparent, both for the present as well as the future, that it is a building and addition of your own day and time.

It is no merely fine figure to say that architecture, like poetry, lives for ever; for how cold and lifeless is all history, in comparison with that which generation after generation writes in its buildings, and how many pages of doubtful story might well be overlapping for a few stories piled one upon another.

Work hard and honestly, carefully seek for the opinions of your fellow labourers, and respect them though they differ with yours; remember that they are probably arrived at by an equal amount of study as that which you yourselves have had, perhaps more, but each man will probably take a different view. Be sure, when you work with all your might and with all your power, in small things as well as in large ones, and gain the goodwill and esteem of the great majority of your fellow men. Steer clear of cliquism, believe not the false prophets who seek toetter design and to keep it in one groove; so for as you enter into the narrow circle of any particular clique, you will become not only artistically but socially contracted—artificial and false in your views of men and things. You will hear, also, some absurd nonsense about art-architects, as compared with architects who understand the surveying portion of their work. Any more absurd pedantry or fallacy than this can hardly be imagined, for it behoves an architect to understand the practical interests of his work, and to carry through all the essentially practical and business parts of it. You must understand not only how to design, but also how to build; you must be able to write a specification carefully and well, so that it shall explain exactly all that is wanted for the construction of any building. In these days, when, particularly in the English law, the ingenuity of the architect is at work, you will have carefully to protect and watch over your client's interests, as regards any damage that is likely to accrue to him through the erection of neighbouring buildings, and to know what liability he will incur by erecting his own; for, be assured, if you know nothing of this, and only call your self an architect, you will get very little work, for no client will employ you unless you are able to guard him against pecuniary or other damage in such matters; and it is not to be supposed that he will care to pay any one else to do what I hold is as essentially a part of an architect's practice as the mere designing of the building. You will require to have the Building Act at your finger's end, to know the laws and rights of light and air, and all the other minutiae, which you will find, and you get into practice, if you follow me.

Nowadays the light and air question is becoming a most important one, and I think demands the serious consideration of the legislature, to make some alteration in the law thereof; for directly you attempt to raise even in a very small degree any old building, or to re-erect it to any greater height, you are probably on all sides by threats of injunctions or actions for damages, or demands for compensation; and although I admit that it would not be at all fair to seriously damage any of your neighbours by really detrimentally obstructing their light and air, yet the absurdly frivolous grounds on which buildings are stopped, and injunctions gained, cannot but seriously affect the chances of any improvements in large towns: and I therefore hope that, ere long, Government will step in with some new Act to lessen what is now becoming a very serious and damaging evil; and, indeed, if something be not done to alter, not only the law of light and air, but also to revise and modify the Building Act, the improvement and rebuilding of London will have to come to a standstill.

You will find also a knowledge of landscape gardening most useful, for every architect should at least be able to select the site which nature has made most appropriate for his building, and often he will be able to help nature by a judicious knowledge of what views should be opened up, what trees should be put here to add water, where to add foliage. You must adapt your building in a measure so as to be in harmony with the surrounding accessories of site, and remember that a good building is too often ruined by injudicious selection of position, and its inappropriate-ness to the scenery which surrounds it.

In commencing practice, be sure always of one thing, that "No man is an island," and do not try to individualize your work, but be courteous to all you have to meet, and whether in discussing the merits or demerits of your own or other men's works, let all criticism be given with fairness and judgment; honesty and straightforwardness in everything will gain the esteem of all, opponents as well as friends—whatever you put your hand to, do it with thy might, make up your mind that right is right and fair, be honest for your client's interests, and swerve not from it, be honest on both sides, and you will find those under you respect you, and be content to abide always by your decision, knowing that they can rely upon your fairness, and those above you will trust you, knowing that you will do them justice.

A young architect has especial need to be careful in all that he does, and it is better to be known as a just man amongst the many, than a sharp man with the few; we are all liable to mistakes, particularly in early practice, therefore be especially careful to ask and take the advice, if necessary, of those who have had more experience, but if you make a mistake, seek not to hide it under the carpet, to pretend it is a contract, but honestly confess it, and meet it in an equable manner.

Learn diligently, and study earnestly, but avoid all superstitious reverence for old times and opinions, or pedantic adherence to routine, which is only too liable to lead you into opposing all new discoveries and increased appliances, and to lose the respect of all thinking people. Remember that you must always be students, learning always, studying always, looking always still further for new knowledge, for no profession demands more ready command of all knowledge, or clearness of conception, than your own work; and work will be changed to individualize, to forecast difficulties, and enhance the pleasures of your daily professional life, and enable you to overcome all the difficulties that may beset your path.

"Nihil difficile amans."

Let your work, then, be associative as well as earnest, to you will come the honour and reward that the hands that work with you, and of "leading forth mind after mind into fellowship with your fancy, and association with your fame," and beyond all this, seek always that it may be said of your work by the generations yet to come, as it has been said of the work of the generations of the past, that it has a "distinct and indisputable glory, by which the might be identified, but by men who loved and aided each other in their weakness; and that all the interlacing strength of vaulted stone had its foundation upon the stronger arches of manly fellowship, and all the changing grace of depressed or lifted pinnacle owed its cadence and completeness to sweeter symmetries of human soul."
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

THE HYDRAULIC LIFT GRAVING DOCK.*

BY EDWIN CLARK, M. Inst. C.E.

(Concluded from page 293.)

Mr. G. P. Bridges, Past President, said, it seemed that this discussion had arisen to a great extent from an expression in the Paper which was hardly consistent with the context. He did not regret that expression, because it had given rise to an interesting discussion. The expression in the Paper was, that the system described was capable of universal application. The more proper expression, perhaps, might have been extensive application. It was not a system, beautiful and perfect in its machinery; but it could be very successfully applied to the design of a dock for the Indus upon any given plan, and there were various conditions which ought to influence any engineer before he recommended its adoption.

Some one had expressed that the expenditure on this dock, as stated in the Paper, was not altogether bona fide. That misapprehension had evidently arisen from the fact that whereas the cost of the lift was stated in the Paper to have been £88,000, somehow or other the expenditure on the dock was very nearly twice as much. If these two statements be taken together, it is not at all unlikely that he and the writer of the note may both be in the right. The expenditure had arisen from the circumstances that the Company had for the land; they also had to pay royalties; and there was also the profit and loss. He did not think he ought to be called upon to give the details of the profit and loss in this instance; it should have been held that engineers should restrict themselves to the mechanical department, leaving those who had to apply the machinery to do it in the most advantageous and economical way they could. Taking, therefore, the sum on which he considered he should be brought for the dock from government, he should have to add to the common cost of the land, and the erection of stores, together with profit and loss, the expenditure would have exceeded the £88,000 stated, by somewhere about £100,000.

Now, then, he thought it had been explained why there had been such a heavy profit and loss account; and yet, he was sorry to say, at this very hour there seemed to be still some disposition to give credence to every idle rumour in respect of these works. It was suggested to him that almost any ship that entered the dock some misadventure happened; and it was also suggested that he was disposed to alarm people into the belief that he was surprised to find it stated, at this late hour, that a vessel in the dock was cumbered or hogged to the extent of 8 inches or 9 inches, and that the vessel afterwards became depressed to a corresponding extent, and was very nearly apprehended to have sunk in the name of the vessel. No name was given, but this remarkable circumstance was said to have taken place upon one of four days. Those four days had been investigated, and it was proved that during those two of those days no vessel was in the dock at all, and it was shown that the statement should not have been made. It was also stated that the dock had been lifted, lowered again, and taken away; and the point was ready for another ship in two hours, and the ship gone. In the establishment of this lift, many of his friends had a pecuniary interest, as well as himself. He said, that they stipulated that the dock would be able to handle every ship whatever in the patent-right of the invention, because, in the first place, the principle of the thing was objectionable, and, in the next place, being engineers, it was not consistent with their position to recommend a thing in which they had a personal interest. He had only one further remark to add: that he looked upon this as one of the greatest engineering feats of the last twenty years. That the system should have been brought so nearly to perfection—worked with so much safety on a first experiment, to his mind, something marvellous. And when he said it was said it was required judicially to guarantee the safety of the dock, and then that the authors of the invention were already reported that upwards of a thousand ships had already been lifted with perfect safety, he thought, that the amount of judicious management required was beyond what could be hoped. Mr. Giles explained that when he stated it took four and a half hours to get a vessel on the pontoon, he did not intend to imply that it required that time to lift the vessel. He should be glad to hear what was the greatest number of vessels lifted in one day.

Mr. J. Scott Russell said he thought it was the general opinion that the Author's invention was a very admirable one; that all the mechanical arrangements were excellent; that the idea was remarkably original, and that it had been carried out in a most successful manner; but he thought the Author did it somewhat of injustice when he brought it before them, if he considered it better than any other description of graveing dock or floating dock, and that it was better than those inclined ships which were also used for repairing ships. They were left to draw the inference that all other plans were either very dear or very bad, and that the Author's plan was the best for repairing ships. He was of opinion that graveing docks were in certain circumstances better and safer than the Hydraulic Lift Graving Docks. He thought that the fact the ordinary Hydraulic Graving docks, not of this description, were in some circumstances more economical and more applicable, and that what are called inclined slips were superior to the arrangement adopted by the Author. He should be sorry to say that the hydraulic lift was not the best thing that could have been invented under the special circumstances of the case.

He would enumerate circumstances in which it appeared to him that the plan under discussion did not possess so great merit as it might otherwise have had, was attributed to the nature of the work.

He submitted that where there was good rise and fall of tide, a shore with deep water close inshore, a soil able to carry the weight of a ship, and not hard to work, good hydraulic lime, and building material cheap at hand, an ordinary granite dock was cheaper in first cost and cheaper in working than a hydraulic lift. Engineers should consider all such circumstances before they abandoned the graving dock. In discussing graveing docks as graveing docks, they should not compare a costly granite graving dock with an economical arrangement.

* Read before the Institution of Civil Engineers.
such as they would make for a private builder. In a tidy way, a dock could be easily made. He recollected having a dock made for the repair of a ship by a tender of the fleet who had leased the yard, alongside the Thames, a space excavated large enough for the size of ship to be repaired. The bottom of that dock was gravel; it was not even lined with timber, and a simple pontoon floated in kept out the tide. But it was a grazing dock with the simplest of means, but the most possible description. Then they had the timber graving dock common amongst shipbuilders, and, finally, the dock lined with brick and granite.

On each side of a gently sloping bank of good solid material shelving downward continuously into deep water at an angle between 1 in 24 or 1 in 50, or 1 in 60, the patent slip, as it was called, applied to him better and cheaper than the hydraulic pontoon dock. In such a place they nothing to do but lay down the ways and haul up the ship, and with a crane they could have a ship up a point at a time. A twenty-fourth part of the weight of the ship would overcome the friction of the ways. If they put the vessel upon rails, they need not say that one-fiftieth of the weight of the ship would overcome the resistance of the ways; and in that case, which was not the usual form of slip, a system of slips and carriages had been used, by which the ship was raised by a system of wheels and chains, an expense in the way of capital of £2 per ton of the ship, it would be seen that that was very economical arrangement. With regard to a graving dock, it would cost a great deal more: it might cost £5 per ton of coal at the dock in.

The last arrangement of which they had the choice, independently of the Author, was the ordinary floating dock, and the question was raised, in what circumstances was the ordinary floating dock better than that under those conditions, and was one practical? For, in the ordinary Lift Graving Dock and the ordinary floating dock, and it consisted in the comparatively small depth and great breadth of the pontoon; in the Author's he believed it was 6 ft. deep by 60 ft. wide and 300 ft. long. The depth of this part of the vessel was 6 ft. the Author included the depth of the water in the draft, and the machinery which raised and lowered her. The Author sank a series of cylinders, each containing a hydraulic ram, and the pressure was connected with a piston in the cylinder, the whole of this apparatus was raised and lowered, and was gradually lowered into the water. After the platform was supplemented with water, no more force was necessary to lower and raise it, and therefore the machinery was simple, and had the least possible friction; but the moment he placed a vessel on the top of the pontoon, the cost and labour of raising up the ship out of the water was incurred, and for that purpose it was supported in various ingenious ways, which had been explained. In the ordinary floating dock, instead of the hydraulic apparatus being fastened to the ground, it was put on the top of the dock, and in the shape of a lift, and there was much more water out of the pontoon as equal to the weight of the ship raised above the water. In a plan previously explained, instead of these pontoon being filled with water, the platform had been lowered by scows and water, and these inventions had been used for lowering the platform and for raising it.

As regarded the Hydraulic Lift Graving Dock and the ordinary floating dock, the circumstances of position were, in his opinion, of more importance than the mechanical arrangement. For example, when a shallow water was abundant, where an extensive area of sheltered water existed, where there were no tides, and where foundations were met with at so great depth under the water, the Author's invention was most applicable. Put into a rocky shore, as at Bermuda, or a had foundation and great depth of water, then the ordinary floating dock was the best arrangement, and for such a position the Author's was not a good arrangement. The former condition, favourable to the Author's arrangement, was the case in the Victoria Docks at Birkenhead, and the dock, which was considered the most valuable part of the hydraulic lift, on which he placed great weight, even more than the Author himself did, consisted in the multitude of ships which could be floated in shallow water at comparatively small expense. The Author, as it were, a single dock with its apparatus, and by this single dock and apparatus he had incurred the greater part of the expense and outlay; for, by a simple method of detaching from this fixed apparatus the floating pontoon, he might be able to multiply its use and to improve by an operation for the same length of time the way in which it was done was this. The shallow dock had a level bottom, and by running the water out of the shallow dock, the pontoon was brought down and grounded upon the floor of the dock. Then there was carried from the shore timber 200, 300, 400, or more, exactly the same, perfectly true, to make a shipbuilder to finish his vessels; and no better scheme could be conceived, either for cutting a ship in two and lengthening her in the middle, or for building a ship outright; and he believed the system would come into general use for shipsbuilding. The accident that had just occurred to the "Northumberland" could not have happened if the

He begged to thank the Institution for the time which had been devoted to the discussion, and for the kind manner in which his Paper had been listened to, and he would add that, although he had pointed out no less than nine features in which this kind of dock possessed advantages over others, yet the principal point which he had stressed was the question of cost. He knew that a great deal of the discussion which had arisen, from the manner in which the subject had been treated. Throughout the discussion a dock had been spoken of as costing so much money, without regarding the dimensions of the dock. It would be as definite a mistake to assume that a ship was worth so much, or to take elasticity, which was not the usual form of slip, a system of slips and carriages had been used, by which the ship was raised by a system of wheels and chains, an expense in the way of capital of £2 per ton of the ship, it would be seen that that was a very economical arrangement. With regard to a graving dock, it would cost a great deal more: it might cost £5 per ton of coal at the dock in.

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THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

had been lowered on a pontoon instead of by the ordinary way of launching; and the American Government attached so much importance to that plan that they adopted it for launching their vessels; and he was sure the interest upon the cost of the pontoon would be far less than the expenditure required to prepare the berth for the purpose of carrying the pontoon with so much timber cut to waste, not to speak of the risk that must attend the launching of vessels of such great weight. Then, again, by the use of pontoons, the number of places where ships could be built was multiplied, and the shore timber increased, in which the cost of the pontoon would float, might be employed for the building of the largest ships, and in the launching a small lift only would be required. To launch the "Northumberland," a 1,000-ton lift would be sufficient.

With regard to general request that he would point out the differences between the system of raising with hydraulic power and that of simply emptying the pontoon of water, he would occupy a few minutes in explaining clearly, he hoped, the difference between the two. With any floating body, such as an ordinary pontoon, the stability depended upon the fact that some portion was out of water, and any change of position produced extra immersion or emersion in that part; but when a body was entirely submerged, no change of position could produce any difference in that respect, and a submerged body had consequently no stability; walking trot one side to the other would tilt a submerged pontoon, unless it was forcibly maintained in a horizontal position. One of the plans suggested was the parallel motion, which had been tried at the London Docks, the rod being attached to the pontoon and to the bottom of the dock. This pontoon was on the iron rive, and the position of which was to maintain the horizontality of the ship. This plan failed; the strain on those rods, which varied as the tangent of the angle made with the vertical, becoming very great as the water closed, and ultimately breaking the ship's side. The other plan was the one of forcing the water in, and through the bottom of the vessel; the water could not be pumped out; and in subsequently trying to force in air, the deck was blown out. The other system usually adopted for rendering the position stable was to make hollows sufficiently high and of sufficient depth to carry partly out of water. The sides were, 40 feet high. In these towers were placed hollow boxes, which by means of screws, or chains, or some other contrivance, could be raised or lowered. The consequence was, unless the ship was dry, the weight of the water in the vessel could be lowered, and the stability maintained, so long as both chains were lengthened to the same amount and at the same time. In that way the stability was maintained in the American Canal Dock. Sometimes this was done in the form of a large chamber, which had to be filled with water. In all these cases, a great difference would be observed between this pontoon and his own. The pontoon he used was perfectly open; it was never subjected to a greater strain than a pressure equal to the draught of water it drew; and, drawing 6 ft. of water, the general pressure was, therefore, 6 feet to the 3 feet. He thought a consequent weightless and inexpensive; but in lifting with a submerged pontoon, it must be sunk 25 ft. or 30 ft. deep in the water, and, therefore, being subjected to a proportionate pressure, the quantity of iron required to strengthen it, and defend the deck against the pressure of the water, would be more costly than the whole of the presses and pumps put together. Then, in addition, the manipulation of a large number of these boxes required a large staff of assistants. If a vessel were 300 ft. long, with eighteen boxes, about forty men would be required to work them. It was an engineering operation, requiring much skill and management, and, after all, it was only one dock; but with his plan, twenty pontoons might be worked by a single lift, with six men.

He did not design the work for universal application; he agreed that there were many circumstances in which docks of another description were better. There were many cases in which a slip would be better than his dock, or any other dock, and there were other cases where a stone dock would be better than this lift; still it was capable of very great application. The principal difficulty was in respect of the cost of the iron columns, where the water was too deep; and to meet such cases, Mr. Walker had suggested the plan of putting the presses themselves in water, but where the water was of sufficient depth there were few cases in which a dock of this kind would not be far more economical than an ordinary stone dock.

With respect to the stiffness of pontoons, he wished to state that in advocating the use of pontoons he was perfectly aware of the matter. He had stated that, from the experience of more than a thousand ships, an elastic pontoon was best, and produced no strain; but if a rigid pontoon was wished for, there was nothing to prevent the sides being made 5 ft. or 6 ft. of water. In the amount of water out of which a captain wanted to launch his vessel, he always preferred to do so on a soft place; but that was a matter of judgment. A great deal had been said with regard to the commercial failure of this undertaking, and he thought that subject should receive much more attention; that subject did he think it concerned him. An engineer might construct a superior quarter-crushing machine, but it might be sent to a bad gold mine. If proper use was not made of the hydraulic lift machine, he was sorry for it.

To return to the subject of cost, he wished to put the matter in a simple form. The cost of lift, engine, pumps, and all complete and fixed, would not exceed £10 per ton upon the weight to be floated. The cost, therefore, of a lift for vessels of 1,000 tons would be £10,000; and the cost of six pontoons of from 500 tons burden to 1,000 tons burden, would be £22,500. Thus six docks were respectively completed for £32,500, allowing a good margin of prid to the manufacturer. This was in the case of a lift not requiring more than ordinary excavation. If a great amount of excavation in difficult ground was required, as in the Victoria Docks, of course it increased the cost. If it were done at a place like Birkenhead, where the value of the stone was considerable, the amount of excavation, and the cost of excavation, he imagined there must be great economy of cost.

Mr. Abercrombie remarked that the Author had omitted comparison with the two docks at Falmouth, which were lined with granite throughout, and cost £250,000.

Mr. Clarke said that in his illustration there were six docks adaptable to almost any situation, and capable of indefinite extension by adding to the number of pontoons. The machinery was simple and durable in all its parts. In comparison with ordinary floating docks, the whole of the work was perfectly accessible, especially with regard to the painting of the iron work, as there were no closed chambers, and the pontoon was raised out of water in every operation. The rapidity with which this description of dock could be constructed was another important feature. The dock at Carthagena, in the model, was stated to have been commenced in the year 1861; and now, in 1866, Mr. Rennie had been good enough to promise a descriptive paper with the dock was completed. It did not take more than a year at fastest to put together the iron framework of the dock, and build any-where in that time. He did not know what the cost of the dock at Carthagena would be, but he was told it would be about £200,000.

ON THE DECAY OF MATERIALS IN TROPICAL CLIMATES, AND THE METHODS EMPLOYED FOR ARRESTING AND PREVENTING IT.*

By WILLIAM JENNY WALKER, HEATH, ASSOC. Inst. C.E.

It is proposed in this Paper to allude to those materials which are most used in the construction of permanent buildings, and such as have come under the immediate notice of the Author, or for one residence in Ceylon extending over a period of seven years.

The habitations of the lower class of natives are constructed of a rude framework of stout bamboo, the sides and roof formed of reeds, and closed in with the interwoven leaves of the cocoanut palm (Cajdlus), laid on after the manner of weather-boarding, see fig. 1. The dock at Carthagena, as the material, formed of the twisted fibres of the husk of the cocoo-nut. In the ordinary course, the cajdlus require renewing every year; but these leaves may be made to last two or even three years by washing them over with the slimy juice of the 'bellic' (a native fruit), which when dry resembles copal varnish, and acts, to a considerate extent, as a preservative against the weather.

The framework of the huts, built of 'wattle and dab,' is made of roughly-squared jungle-trees, morticed and tenoned with some care, and secured by trenails. Small twigs are tied with coir, in parallel rows, vertically and horizontally, both on the inner and the outer sides of the framing. The space between is filled with clay and sand, well kneaded, and, when nearly dry, both the inside and the outside of the hut are covered with the same material. It is then plastered over with earth, which has been thrown up by white ants, after being mixed with a powerful binding substance (produced by the ants themselves), and through which the rain and moisture cannot penetrate. This will hold the walls together, when the entire framework and the wattles have been eaten, or have become decayed.

The material of which the walls of the superior houses and other buildings is built is called 'coback,' a soft kind of rock, found in most parts of Ceylon, at a few feet below the surface of the land. A large square is cut into, the rock laid bare, when it is quarried, by means of a pickaxe, into blocks of a convenient size for transport, or of the size which will best suit the building for which it is intended. Coback has the appearance of a coarse sponge, the material of the sponge resembling red iron ore, and the interstices being filled with soft, yellow, or white, clay. The work should be exposed to the rain before being used, so as to allow some of the clay to be washed out, as then a better face for the mortar to adhere to is formed. Buildings of coback require protection from the weather, but, if covered with a thin coating of lime-plaster, they will stand for many years. When removing some

* Read before the Institution of Civil Engineers.
old Dutch buildings, the cabook did not appear to have deteriorated in quality.

Hard kinds of stone are not much used for buildings, on account of the expense of working. Rubble masonry is some times still used, but it is not well adapted for the durability of obtaining even beds and good bond. The cathedral church of St. Thomas, near Colombo, is an instance of the successful adoption of rubble masonry. It has now been built upwards of ten years, and is in a good state of preservation, having the appearance of having been recently built. The burnt, and the clay is so badly puddled, that brickwork will often, after a shower of rain, scarcely bear the least weight without crushing. Although used in some instances with its surface exposed to the influence of the weather, it will undoubtedly exist for a much longer time, if well plastered with lime-mortar. Two or three coats of boiled linseed oil will preserve brickwork without hiding it, but the expense prevents its general adoption. A coating of coal tar, applied when the day is fine, and the brickwork dry and hot, is also a good preservative: but it cannot, on account of its unsightly appearance, be often employed. Brickwork in exposed situations and unprotected will perish very rapidly. The sober brick will if hollowed out, be left to the mercy of the elements; and in damp places the bricks will in less than a month be covered with lichen.

The lime generally used is made by calcining white coral, of which there is an abundant supply on the coast, easily obtained. The lime is the main ingredient in cement, and the kiln is a fine white powder, and is in that state ready for immediate use, by mixing it with twice its own bulk of sand and water; but it sets rapidly, and the bricks have to be kept quite wet, and water has to be continually added, to prevent its setting before the bricks are truly placed. In the Public Works Department, the lime is placed in a tank, and kept under water for two days before being used; this makes it longer in setting, but it is more easily worked, and eventually makes better work. In fact, by the first plan it often simply dries, and is very friable; but in the latter case it sets equal to the best blue lime. In using this coral lime for plastering, it is better not to slack it for more than ten minutes, as it persists a longer, and will bear a high polish, almost like white marble. A short time ago the exterior of public buildings was painted, but this practice has been discontinued, as it answered no good end, and, after a few months, generally presented a bad appearance.

Timber, well seasoned, and built so as to have free ventilation, will last away for many years, though not for so long a time as in England. The best wood for general use is Maulmein teak. It begins to fail in about twenty-five years, but the decay is very slow, for after a hundred years, it is still in tolerably good condition. It would appear that woodwork lasts longest when no precautions are taken to preserve it. In general, it is subject to the white ants, and when subject to them, the white ant, it is best preserved by a dressing of Stockholm tar, which is easily applied, and which, owing to the heat, is so limp as to insinuate itself into all small sun-cracks or fissures. Several substances, such as corrosive sublimate, have been used with success; but the cost precludes their use, except in cases where a second coating of tar cannot be easily applied. In sea-water, timber is speedily attacked by worms. The piles of the jetties in Colombo Harbour, which are mostly of satinwood, and about 14 inches in diameter, are so pierced in the course of twelve months as to require renewal. There is also a very small worm in the fresh-water lakes and canals, which infects the bottoms of boats, &c., the logs of which cannot be painted, oiled, or tarred. Creosoted timber is not attacked by white ants, but the black coating, if exposed, renders it so heat-absorbing that it is apt to split, and, unless thoroughly impregnated with the creosote, a road is opened to the inside, and the ants will soon destroy all that part which is unprotected. Unprotected timbers near the sea does not warp or split so much as when removed inland; the changes from wet to dry not being so sudden in the former situation.

Iron exposed to the influence of the varying weather, speedily oxidizes, but not to so great an extent in the same time as in England. Painting, if applied at home, is well at a time, but if applied in Ceylon it is not so effectual. Oil applied hot is a good preventative; but when applied cold, or in the same way as paint, it is of little avail, because the iron oxidises under the paint or oil. Coal tar is by far the best covering, applied either cold or hot, before or even after oxidizing has commenced. In the first condition it prevents, and in the latter arrests, nearly all tendency to rust. The heat, which contracts the oil or paint, causing minute fissures that admit moisture, in the second, that which was necessary to prevent any small part of the timber from being uncovered in the operation of tarring to be flushed over with a thin coating. The most valuable timber in Ceylon is quickly decayed by contact with unprepared iron; so that screws, nails, or spikes, unless well greased or tarred, may in an incredibly short time be easily drawn out, the wood surrounding them being quite rotten.

Ordinary galvanized sheet-iron does not last many years, except it be protected with good red-lead paint, frequently renewed.

Lead-piping that has been four years in the island is still nearly as bright as when the pipes were first drawn. Brass oxidizes, and becomes very brittle, in a much shorter time than in England. Lacquer is the only preventative applied for the first defect, and for the second, the brass is heated nearly to a red heat, and then dipped in cold water. Zinc is a most durable material; it will last for many years with little or no apparent decay. Glass exfoliates in a short time. It requires constant care to preserve the lenses of optical instruments. Tripoli powder on the hand will remove the exfoliation.

Paper is easily affected by the moisture of the atmosphere. It loses its size, the surface becomes rough, and in a short time is so absorbent as to render it impossible either to write or to draw on it. It requires to be kept in a close and dry place, and only so much of it should be exposed as may be required for immediate use. Leather, unless well "dubbed," becomes so brittle, as to break short off like a piece of wood. Gutta-percha, in about twelve months, is so brittle as to break like glass, but more easily; and after about three years, it may be reduced to powder. Mastic, and other gums, unless immersed in hot water, will arrest this decay, but articles the shape of which would suffer by the heat must be left to their fate.

Mr. Buckingham remarked that he had sent out to Bombay both creosoted and kyanised sleepers; native jungle-wood had also been used. He regretted he could not give the details of the results of these several experiments. He could, however, state the general fact, which was of much practical value: the resident engineer of the Great Indian Peninsula Railway, after an experience of thirteen years in India, was now replacing large numbers of sleepers which had failed with teak and iron sleepers. Attempts were made in the first instance to preserve the native wood by means of various processes; but it proved that, on account of the wood being so hard and close-grained, it was impossible to impregnate it sufficiently with the preservative material.

Keys were a matter of considerable difficulty in warm and variable climates. It had become usual to him that the wooden keys (which were, he feared, perhaps not made with the utmost care) dropped out in great numbers, and he was now giving his attention to the introduction of some other kind of key, which would answer the purpose better than the wooden ones.

With respect to the preservation of iron, the result of his experience was, that whether for rails or bridge-work, iron should be thoroughly cleaned and dried by heat, and then dipped into hot linseed oil. In the first instance, iron work was sent out to Bombay not so treated, and the oxidation was excessive; but since that plan had been adopted the oxidation was prevented, and the rails and other ironwork remained in a perfect state.

On the subject of rolling stock, it was stated in Mr. Mann's paper that the carriages on the Great Indian Peninsula Railway, were sent out with teak panels. If that were so, it was at a very early period, and before he had much voice in the matter. For some years past the carriages had been sent out with "papered" keys, of which he expressed his own opinion that it was the best material for the purpose, the locomotive superintendent, who ought to know better than himself, had expressed a desire that the panels should be of teak, and not of "papier mâché."

Mr. Irwin, the Past President, said he had spent three years of his early life in a tropical climate, close to the equator, and had some experience with regard to what timber would do in a country which Humboldt declared to be the hottest part of the world. He had also had many years' experience of Indian and of foreign railways, and of the construction of the rolling stock, sleepers, and iron-work sent out to those countries.

He would say with regard to timber generally, that, being an organic substance, it was impossible for any one to predict what it would sustain under the varying circumstances in which it was employed in those countries, or, indeed, elsewhere. For instance, he had known * See ante p. 299.
yellow pine, which, according to the statements of joiners, was not a good wood, last in railway sleepers for twenty-five years, and at the end of that period it was as sound as any of the specimens that had been exhibited by Mr. Mann. The reason for the iron pot sleepers being used for only ten years. Dealing with timber was something like dealing with the human constitution; it was impossible to tell what or how many incipient seeds of decay it might contain.

His walk enabled him to see some of the woods exhibited. He had seen some of these hard woods which, under certain circumstances, lasted as long as the piles from the Recife jetty; under other circumstances, from causes which he could not explain, the same descriptions of wood had sometimes decayed in a much shorter time than that appeared to the iron pots. He remembered the railway chiefs of the railways, that were required in the construction of railways in tropical climates, if native timber were used, it was bought without knowledge, of the soil in which it was grown, or at what period of the year it was cut and placed up to dry; the present writer, however, based his judgment on the knowledge of the wood, but it was one of those subjects on which it was not safe to draw such large general conclusions as had been done in Mr. Mann's paper.

With regard to the question of sleepers, whether half-round or square, he could not understand on what principle the former should be more durable than the latter.

Mr. Mann said, the half-round sleepers were more durable than those of the square kind, because, independently of the half-round shape allowing of better drainage, the wood was less of a closer grain than the square sleepers.

Mr. Hawkhaw, Past-President, observed, with respect to the preservation of iron-work, that he could not agree with the suggestion that galvanizing was done for the preservation of the iron pots. The work was done to give it a resistant coating of galvanized iron, and he was willing to confess, in some cases unfortunately, and, therefore, he had less hesitation in stating his opinion of it. He had put up roofs of galvanized iron, and found them decay much more slowly than those coated with bitumen. He did not recommend that iron pots be sent to India should always be subjected to that process in preference to oiling and painting. The other suggestions were very proper. The iron should be well cleaned and dried before painting, for wet or rusted iron was covered with very weak coatings, and would last much longer in the tropical climates than when the unfortunate precipitate had been used. No doubt, in tropical climates, there was a difficulty in making durable works, either of iron or wood. He had tried almost every material for sleepers, native woods, and woods of this country, and Baltic timber creosoted and not creosoted, and he confessed he had not derived much better results from one than from another; and he had been driven to the conclusion that in the tropics iron was pretty nearly the only thing that could be employed for sleepers with anything like certainty as to the results. He quite agreed in the opinion that more rigid permanent way. Rigid ways were not liked in this country, and by necessity brought him to the conclusion that a durable road could not be made in tropical climates, except by the use of iron. Iron sleepers, he believed, were recommended by many of the contractors in the world; he was the first to use the iron pots in England, and he found them rigid and did not like them; but necessity obliged him to use them in tropical climates; and he was afraid, notwithstanding all the care in selecting native woods, creosoting foreign woods, and taking every other precaution, it would be necessary to use iron very extensively in tropical climates. When in Egypt, he saw the line constructed by the late Mr. Robert Stephenson with creases in the iron pots, which, after great consideration. Mr. Stephenson adopted as the best compromise he could make. Those sleepers had been laid, he believed, more than ten years, and the line was a good and substantial one, and the sleepers stood well. Iron sleepers broke only when not made strong enough; but it would be easy to make iron sleepers that would not break; and where that was not required to be more than 8 in 36 or 40 per hour, he saw no reason why iron sleepers should not be used. Whether, ultimately, a better material would be discovered, he could not tell. With regard to the laming of the rails, he could not see what the temperate climate had to do with it. The temperature must be 100° or 60°, could make little difference; nor did he think that the use of steel could be more beneficial or necessary in a tropical climate than in his own country. Steel was better than iron anywhere; but there was no return in tropics when the wood was used to stand more than one third, or 10 lbs. 36 per ton of iron, but was said to rest were suspended. It did not seem to be understood that when a cross girder was made to rest upon the flange of a main girder, the flange on which it rested was suspended from the vertical web by rivets.

Mr. James Bunlles said, during a short stay he had made in the Brazil, he had an opportunity of observing the different qualities of timber, some of which he recognised in the specimens exhibited; but he had not had much experience as to the durability or otherwise of these woods. On 5 miles of the San Paulo Railway he had laid sleepers of native timber, and by the last reports he was informed that, after having been in use two years, they were decaying very rapidly. On the other hand, he had a section of line 4 miles in length, laid with Feuerbach iron pots, which stood as well as the other iron-work he sent out, were bailed in a preparation of tar and asphalt before being shipped, and he found that treatment was a good preservative against rust. He had used the same kind of preparation for the iron pots, and he thought that it was better material than iron, either for the permanent way or for bridges, and he believed that was the material engineers must mainly depend upon.

Mr. Barlow thought the Institution had reason to be indebted to the Authors for the great care with which they had collected the facts, and for the methodical manner in which they had laid them before the meeting. It struck him that there was a weakness in the argument against resting the cross girders upon the lower flange, the general question of which he would not now discuss; but when girders were laid over the rivets, as was virtually done when the cross girders rested upon the lower flange, it must be recollected that this strain, which was said not to have been calculated, must ultimately come upon those new rivets in the case of the suspended girders.

The writer was struck with the similarity of the experience which had been gained in South America with that which has been gained by engineers in India. There were not so many native woods suitable for sleepers and for other purposes, if there were not so much iron to be used, that might be readily carried from the Caroline Islands and the Monomotapa. In the first instance, if a wood suitable for sleepers was found, there were no roads for getting them to the works, and the only thing that could be done was to send out from Europe either memel creosoted sleepers, which was a most unenviable business, or wait until the iron sleepers were known to be very efficient. He believed, ultimately, when railways were more extensively opened than at present, the renewals might be made with native timber, because there would be more ready access to the forests. He thought the use of the bogie engine, and the other advantages, as well known and known to the greater safety and than could be done without that very useful appliance.

Mr. Hawkhaw, Past-President, remarked that the assumption that creosoted memel sleepers would stand in these climates must not be adopted as correct.

Mr. H. P. Bux said he had been informed that the sleepers first sent out were rather too soft and very poorly well prepared. The best evidence he could give of the general estimation in which creosoted sleepers were still held, was the fact that he had contracts to supply upwards of 400,000 creosoted sleepers in various parts of the world. He had recently been in communication with Sir Macdonald Stephenson on the subject of the preservation of timber. The specifications of nearly all the engineers were for the wood to be creosoted to the extent of 10 lbs. of creosote per cubic foot; but it was found, even with that large quantity, that the centres of the sleepers were not impregnated with the fluid, and some of the failures were, no doubt, attributable to that fact. Sir Macdonald Stephenson had suggested, as a means of obviating that defect, the boring of two holes 1 inch in diameter through each sleeper longitudinally, and impregnating up to 12 lbs. or 14 lbs. per cubic foot. By that means the creosote would be sent all through the sleeper. The boring by hand would be an expensive operation, but he had thought of erecting machinery by which he hoped to effect it at a comparatively small increased cost, and to accomplish the object at a very small expense. Mr. A. M. Rendel, speaking from facts which had been communicated to him rather than from his own personal experience, thought there was no cause for supposing that the deterioration of materials was so excessively rapid in tropical climates. He considered that good materials would last nearly as long as in temperate latitudes. There were as good sleepers in India as in this country, but if mere jungle-wood was used, it would perish in a very short time. Bricks also, if made properly, were as good in India as in this country; but if made after the manner of the country, were extremely perishable.

Mr. Turnbull could corroborate to a certain extent what had just been stated. On the East Indian Railway—of more than 1,000 miles in length—the greatest portion, laid with Feuerbach iron pots, was remarkably well preserved; and a small length with cast-iron sleepers. Although there were various kinds of woods in India suitable for the purpose, such as Simoon, Asson, and other, there was difficulty in getting large quantities of any kind, except Saul, and that wood,
when of good quality, was very durable; but at first there was a great and sudden demand for sleepers, and many young Saul trees were used, as a matter of necessity, with much sap-wood in them, which perished rapidly; otherwise Saul-wood was very durable, when cut out of large timbers, and used in good work. In some instances sleepers for piers in ten years; but he had lately taken up sleepers near Calcutta, which were serviceable after having been in use eleven years. At other parts of the line there were crosseted fir sleepers which had been used for about thirty years, and were still serviceable in less than three years. He had found that, unless the crossing was thoroughly done, and good timber used, fir sleepers were perissiable. Teak was perhaps the best of all Indian woods, but its present scarcity had raised it about equal to 6s. per preclude its use for that purpose. Saul sleepers and crosseted fir sleepers were about half that price. With regard to iron sleepers, he had used flat ones at first, but without success. Greaves - bowl sleepers were more successful, but as yet the experience of them was not sufficient to warrant a general adoption of them. There had, however, been some places, in one year as much as 20 per cent. was reported; but as had been observed, the breakage could be obviated by making the sleepers stronger. He had only laid a comparatively small number of these iron sleepers. He thought, on the whole, it was equally as good as the introduction of these or some kind of iron sleeper, not universally, but partially, in India, from the difficulty of getting large supplies of wooden sleepers, and from the uncertainty of the quality of the timber. A length of one mile in two years had been laid on a single line. One consequence of it consisted merely of a bridge rail bolted to a continuous longitudinal bearing of plate-iron, with a teak wood board between the rail and the plate iron; it had been in use about four years, and seemed to answer totally to expectation, having been made too weak at the joints of the longitudinal bearing.

So many miles of railway in India had already been laid with chairs and wooden cross-sleepers, that a change to iron sleepers would be too expensive to be considered. The loss of the railway in the case of rusting in wood in India, it was a costly process, owing to the difficulty and expense of conveying crosseted from England; iron tanks were necessary to hold the oil when on board ship, and being unsaleable in India, added to the expense. The native woods were generally too hard for penetration; the crosseted did not penetrate the Saul-wood more than 6 inches.

The earth oil, or Arracan oil, seemed as good as crosseted, but the same objections to the difficulty of manufacture and the cost. It was brought from Moulmein and Rangoon generally in leather boxes, or skins. The price is about 6d. per gallon.

General Sir Andrew Wawn regretted he had not come prepared with notes of his experience in India. He had been a short time only in Ceylon, but had visited both Colombo and Galle, and drawn plans of Ceylon, and taken it home. He had not visited the north and the east, but the north and the east. He had been enough to know the country thoroughly, and to judge of the state of the roads and the state of the country. He had visited the north and the east, which he had found in a very good state, and had been able to judge of the state of the roads and the state of the country. He had visited the north and the east, which he had found in a very good state, and had been able to judge of the state of the roads and the state of the country.

Colonel Salt remarked that the results generally mentioned were such as he could corroborate from his own experience; that timber sent from this country to a tropical climate should be prepared beforehand, and that perhaps crossing was the best method. Simply paying over time to the timber did not seem to be advantageous in India. In using timber for building purposes, it was necessary to provide for the ventilation of the ends of the timbers, by which means it would last considerably longer, than if the ends were let into the work without the advantage of ventilation. He had seen the most of his timber on the north and the west provinces of India; teak was both scarce and expensive there. In fact, it might be said that the timber generally used in the works of the public departments in those provinces. The results mentioned in the first paper, as occurring in Brazil, he had observed everywhere, and much more so.

Mr. C. H. Gascoyne, V.P., thought they were much indebted to Mr. Heath, as a young member of the Institution, and of the profession, for the practical observation which he had brought to bear on the subject and for his general reports on the subject. He thought that this general but independent agreement between the results of Mr. Mann and Mr. Heath added another confirmation that the difference between them seemed to be as to the use of galvanized iron, of which Mr. Mann gave a favourable opinion, while Mr. Heath, speaking as he did, seemed to have been influenced by the experience of England, and to have considered the iron as too expensive. He thought that the use of galvanized iron was not sufficient for the purpose for which it was intended. Mr. Heath's paper was at first quite striking; viz., that the loss of weight in iron from oxidation had been observed to be less in Ceylon than in England during a period of time. In confirmation of the fact that the weight of iron had been measured in the works of the Ceylon Railway were suspended, a quantity of rails were lying for many months in Ceylon unused, and rails of a similar nature, manufactured at the same place, were lying in South Wales unused; he understood that the Ceylon iron was better than the South Wales iron. As regards the cost per ton rail, it was not less in Ceylon, instead of which the reverse had been found to be the case. He considered Mr. Mann's paper as very interesting, because it brought before them the results of experience of some years in a country in which the climate is not so temperate as in England, and from the independent and careful nature of Mr. Mann's observations, all he had stated was entitled to great respect and consideration. In reference to the use of timber in tropical climates, it had been often observed that the durability of such materials in tropical climates was no greater than in England. It was imagined that where there were great heat, great moisture, and great heat, the effect of the water and the heat would be very great. When the trees were large, they were not as perishable as the smaller plants, which were apt to keep stores of wood for seasoning purposes. It was almost impossible to get a piece of well-seasoned timber for a chair or a table. He could fully corroborate what had been stated by Mr. Turbitt with regard to crosseted. The crosseted was a very hard wood, and would last for a great length of time. The timber in India was a very hard wood, and would last for a great length of time. The timber in India was a very hard wood, and would last for a great length of time.
in rails and tires on the Pernambuco Railway, and he thought they must seek for other causes to account for it. When this railway was projected, the sleeping cars, so generally found there, and it was not proposed, in the first instance, to use flanges, and they had only been applied after a portion of the line was opened for traffic. Again, from atmospheric alterations, and from the difficulty of obtaining raining-bridge trusses from the manufacturers in Brazil. The line was opened for traffic. Mr. C. B. Lawes said, as the result of twelve years' experience of the Brazilian Railways, he agreed generally with the views expressed by Mr. Mann with regard to the preservation of materials; and some of the results stated in the Paper were very satisfactory to him, inasmuch as they bore out the prejudices entertained by the Government on these questions. He alluded more particularly to sleepers. When he first had to deal with this question in Brazil, there was no time to make botanical investigations, nor was there the knowledge available to the railwaymen in South America of the country. He felt it therefore to be his duty to recommend the employment of such material as practical experience in other tropical countries had shown to be good, rather than the adoption of what had not this experience shown to be good. When the adoption of raw material was employed, he had recommended that the north of Europe creosoted. He had also recommended the ‘iron pot’ sleepers, having had the high authority of Mr. Robert Stephenson in their favour, and having also had the opportunity of seeing the recommendations of the Maus des Ondolier du Colleret. That line had now been about eleven years in operation, and he had recently seen some statistics of its maintenance, from which it appeared that the renewals of the pot-sleepers were very small, in fact practically nothing. He had heard of their failure on some Indian lines, but he thought it must be owing to their not being thick enough along the centre line of the pot: he would recommend their being cast with an internal ridge in that direction, somewhat similar to the ridge along the vertebral line of the shell of a turtle.

He agreed with Mr. Gregory, that the time might arrive, when it would be desirable for English Engineers in Brazil tofell timber and prepare it, either by shed-drying or other means, so as to get a really good native timbre. Some of the Against the ‘iron pot’ sleepers, he could have no objection, and Mr. Mann, in comparison with the cost of creosoted timber sent from this country, it was obvious to those acquainted with the financial position of Brazilian railways, that it would be a matter of the greatest importance to the railwaymen to select that material which was the cheapest available, and he was glad to hear the remarks made by Mr. Gregory in favour of ‘fish joints’, and that he had been partially the injury to the rails of the Pernambuco Railway to the absence of ‘fish joints’ in the earlier stages of the line. Mr. Mann (Mr. Lane) some pains to get them introduced into that country.

With respect to the carriages which were sent out about seven or eight years ago, now referred to by Mr. Mann, Mr. C. B. Lane had at that time himself visited the factory where the carriages were built, and would now repeat that he never saw carriages more commodious or better designed for the peculiarities of the climate and the country. With regard to the whole, he did not think there need be much ado about the matter. In this instance of this wood, he was glad to see that the carriages were of a kind which would have adapted to all the local conditions. He had seen many old timber structures in that country unaffected by them, and, as far as his experience and observation went, he thought timber of good quality, which was subject to frequent shaking or vibration, was tolerable, under the circumstances. He could confirm what had been stated as to bricks, both at Pernambuco and in other parts of Brazil. At Rio de Janeiro he had seen buildings comparatively new, which looked like handsome masonry, the mortar joints standing out, and the bricks tenacious enough to stand an iron in a short time, and would resemble the suspension-bridges over the Seine at Paris. That bridge was erected about twenty years ago from the designs of a very able engineer, a Frenchman named Vaublant, who at that time held the position of Engineer-in-chief to the railway company of Pernambuco, and he felt sure that all the Members would concur with him, that a question of priority M. Vaublant’s name should occupy its proper place in the annals of the Institution.

In his Paper, Mr. De Mornay stated, that he had been assistant Engineer to Mr. Louis Leger Vautier, and that he had made the working drawings during the erection of the suspension-bridge at Casanaga in 1844; of which, speaking entirely from memory, he would give a brief description, as it was an illustration of what he had endeavoured to do. It was a French Engineer of considerable talent, and, at the time he designed that bridge, had not long been engaged by the Brazilian Government as Engineer-in-chief to the province of Pernambuco. The bridge was situated across the mouth of the river, and about 600 feet long, a very wide, constructed of the hard wood of the country, and was formed simply of cross-sleepers, placed at the same distance apart as the suspension-ropes, and covered with rough planks. The ends of the cross-sleepers were placed upon posts which were driven into the river. The Government provided a mass of iron wires, simply laid together and bound round at intervals to keep them in position. Each pair of ropes was connected together by a head, and at the end of the ropes, a large anchor was placed to keep the rods from slipping down the rope. Each rope was composed of four lengths, so that there were in all eight separate ropes—two on each side of the bridge passing over the pillars, and two at each end of the bridge. The whole length of the bridge, about 500 feet, was divided into twelve parts, and each was looped and looped, and then all were connected together, and a length of wrought-iron chain was passed through each eye. Thus, coming in effect two endless ropes passing all around the bridge. The rocking standards were of cast-iron, made in three pieces. The rocking-rod was a segment of a cylinder, resting upon an iron plate; the shaft was made taper at both ends, and cruciform in section, and the capitals served as a saddle for the ropes to rest upon. Four long wrought-iron bolts connected the top piece of the standard with the four corners of the rocking base, and served as diagonal braces to give greater strength to the light cast-iron shaft. The suspension-ropes were of wrought iron, and were placed between the ropes, and attached to strong wrought-iron plates formed to embrace the two ropes. The whole of the work of the bridge, including the cast-iron standards, was executed in the country. The wire of which the ropes were composed was purchased in England. They were not purchased in pieces as was the case with the cast and wrought-iron. The bridge was estimated to cost 40 contos of reis (about £6,500), and its actual cost was between £5,000 and £6,000.

Mr. Bruce, after Mr. Mann, believed, that the rigidity of the ‘pot’ sleepers was due not to the fact of their being made of cast-iron, but mainly to the imperfect way in which the rails were secured to the top of the bow in the wooden keys. The wooden keys, from exposure to the sun and the rain, and from the vibration of trains, soon worked loose; the rail would then rock and the sleeper would loosen. The passing trains being thus enabled to spring the rails, gave a series of successive blows to the top of the bow, which was the chief cause of the solidity and rigidity of the pot sleepers now in use. He thought, that the heaviest construction of this kind was needed for the southern roads, and that he therefore succeeded in doing so by casting the ‘pot’ in two pieces, with a sufficient length of chair-jaw to firmly grasp the sides of the rail, by keying up through legs cast on to the bow or underneath the bottom of the rail. He thought that the pot bearing surface was credited with defects that did not necessarily belong to it. The ‘pot’ sleeper was the only iron road he was aware of that was embodied well in the ballast, and which, therefore, had sufficient hold; and he knew of no other form of an iron road that was likely to support a heavier load.

Mr. Mann, in his Paper, gave such an interesting and varied information respecting the relative durability of materials in tropical climates, as he had no experience on the subject. Mr. Gregory had correctly stated that the durability of wood depended very much upon whether it was, from its nature or situation, subject to be alternately wet and dry, or further upon whether it was soft or hard wood. There was no doubt, that a piece of wood which was wet one day and dry the next, and exposed to considerable heat, was liable to decay very rapidly; and, in the use of materials which were subject to wet and dry, it was very hard, and which, from having all the pores filled up with ligneous matter, did not so freely absorb moisture. A piece of unprepared hard wood was not liable to get wet or dry so frequently because it did not absorb moisture; its rigidity was, therefore, increased by the reverse when wood was selected for creosoting, and it was to that particular point he had often urged the attention of Engineers, but he was sorry to say, as far as sleepers were concerned, with little effect. In fact, the precautions taken for sleepers for foreign railways had been of such a character, that he felt it was utterly impossible to comply
with them. These specifications described the sleepers to be entirely of heart wood, and, as far as he could, and as often as possible, per cubic foot. If the heart-wood sleepers were employed it was impossible to crook them to that extent, and he defied any one to get 10 lbs. per cubic foot into heart-wood timber. He had samples in his possession, which tended to show that the great value in crooking was retained the more, the more important was the work. Such an advantage as much as possible, the work was carried on as often described, a chemical process entirely. It was to a certain extent, because the crook in the oval was the strongest of any timbers of the sap in the oak. But that was not his only idea when he introduced a process that obviated the crook in the piece. wood, the wood so treated became very much more solid and hard than heart-wood itself. That result was fully shown by some specimens of oak which had been used by the admirals of the Italian navy for expert- as strong, though it had lost its heart, because, from the thorough impr- egnation of the bitumen, the young wood had become so hard that it was more like an iron pipe; and he was satisfied that it was lost all the harm that the wood had gone to twice as well as the heart-wood; and as only stated in Mr. Mann's Paper, that the half-round crooked sleepers lasted better than those of the square form; and this result was to be expected, because the half-round sleeper retained all the young wood, and would have more crook in it; but in the square sleeper it was cut out of a might state that during the last six years, extensive experiments had been carried on by Monsieur Crepin, the Government Engineer, at the harbour at Ostend, for the purpose of testing the different preservative preparations against the attack of sea-woods on wood, and the result of those experiments was that wood prepared with corrosive sublimate, or copper, suffered as much from the ravages of the worm as untreated wood; for though the worm did not affect the timber immediately, yet it did so in a short time; but the crooked wood the worms did not touch, and as it lies in an oxygenated state of heart-wood, the crook of the resinous wood reached. The result of those experiments led to the conclusion, that piles used in sea-water should not be squared, but should retain as much young wood in them as possible; and the reason was not because it was better for new work, but if that young wood was cut off, and only the heart-wood left, the crook could not get into it. The engineer to whom he alluded strongly recommended that all piles used permanently in sea-works should be heart-wood sleepers.

Mr. SHIELS had examined some timber bridges in Peruambuco during a short visit to that country, and in one, which had only been constructed three years, he found the ends of the timber had been placed in contact with the chimney where they were liable to be attacked; he found that the wood was almost filled with white ants. He had no doubt the decay was augmented by the contact of the wood with the moist clay. In such a case he would have taken care that the ends of the timbers were not left to the heart-wood, and the wood was almost filled with white ants. He had seen in the tunnels of timber where the wood rested was dry and well drained. At Bahia he had opportunities of making more extensive observations; and timber there appeared to him to be less affected, generally, by the white ant than in Peruambuco. It had been ascertained that timber was preserved for a considerable time by being embedded to the depth of about 2 feet in the sea-sand, which protected it also from the attack of the teredo. Timber was stored for the Government works in considerable quantities in that way, and, having in some instances been forgotten, disclosed itself on the removal of the more. That fact showed that timber, when wholly embedded in such situations, was suitable for piled foundations, and might also be applied economically by those who had wharves or jetties to build in that country, by forming the under-ground part of the piles of timber, and superposing per cubit, and timber, and it had had opportunities, in the earlier part of his life, of making observations upon Australian timber, and it showed the difference of effects between one climate and another, that in Brazil the more porous and open wood was most subject to attack; but in that in Australia it was the reverse, for there it was the hardest description of timber that those insects first attacked. There was one wood in particular in common use to which the remark applied, it was called Teak, and its density in its natural state. It was also and its strength was extraordinary, almost approaching to that of inferior iron in tensility and resistance to strain. It was this wood the white ants particularly attacked. He had had the evil of coal-tar in destroying white ants. He had taken six built bridges of timber where the ants had commenced operations, and tried the system of pouring a very small stream of coal-tar through the heart of the timber which the ants had broken up with their biting teeth. He found the white ants completely destroyed; they were shrivelled up like abstracts of half-burnt paper by the mere effluvium of the coal-tar, and after that experiment he never rejected a piece of timber because the ants had broken up with their biting teeth. As the ants previously the custom, whilst he was able to destroy them thoroughly in that cheap way. It was to be remarked, with regard to the timber of Brazil, that it was very brittle; and his experience there led him to the conclusion that the best course for an engineer to follow was, as much as possible, to have his materials from England, and that iron-work and iron sleepers were peculiarly adapted for a country of that kind. It occurred to him even now that for tropical climates wrought iron transverse sleepers, if it were possible to make them within reasonable cost, would be the best form of support way, and the wood then should not be employed to design something of that sort. With respect to the suspension of the cross-girders of iron bridges from the outer flange of the main girder, instead of from the vertical web, he thought Mr. Mann was right in the use of iron sleepers. It was better to put the timbers to suspend it from the flange, but that the correct reason for that opinion had not been stated. The true reason was, that if the cross-girders were attached to the vertical web, they were suspended not from the head but from the bottom. In the main girder, they would be suspended not by the shank but by the head. He thought every practical man knew that the weakest part of a bolt was the head or nut, and especially so when it was exposed to any sudden shock. He did not think it would be a very great saving in the expense, nor very tight, and the friction occurred generally at the nut, but never in the shank. In attaching cross-girders to the vertical web, the bolt or rivet must be carried through the shank before a failure should occur. With regard to the white ants, he was only employed in keeping the work together, and were therefore only subject to slight strains. Indeed, if both heads were knocked off the rivet, the bolt would be suspended good if suspended from the shank, but would work under much greater stress if suspended from the head. For that reason, he thought girders were better suspended from the vertical web (the proper amount of rivetting being, of course, provided as much in one case as the other), as in so doing there would be the least through the shank of the rivet, which presented greater resistance than the head, and was a safer plan for with- standing the jarring of railway trains.

Mr. JOHN CALVERT remarked that a residence of twenty years in tropical climates had given him some insight into the decay of materials, and he believed there was no more truth in the belief of the American author, and he would state a few facts that had come under his observation.

With regard to timber as sleepers, he remembered that eighteen years ago the Jamaica line was laid with kyanized sleepers, but in less than two months they were all decayed, after which the course was laid to the native "cashaw" wood, a species of the scacia something like mahogany in appearance, and as hard. The timber was sawn down the centre, and laid with the flat side down, and the sleepers had lasted twenty years to the time of this paper; the same is true of the Punjab, called Babool, which formed the principal fuel for the steamer on the Indus and Chenab rivers. It was proposed to use it for sleepers also on the Mooltan and Lahore line, but it was doubtful if a sufficient supply could be obtained. With respect to the imported diptera, they were used as a thing of a bitter taste injected into the fibre prevented their attacks, though one might not have the same effect as coal-tar; but even a small quantity of turpentine had the effect of killing them instantly. The timbers of a house were not so readily than the sleepers, but by rot.

He could confirm the statement regarding to hard woods, that the black ants of the West Indies were more destructive in that quality of wood than in soft, and attacked certain kinds of wood with great voracity. In building a new old cathedral at Jamaica, some of the timbers of the roof, which were of hard wood, were eaten away, and a cart-load of nests formed by the ants was removed, after being cut away with great labour by hatchets. There were some descriptions of wood which he had found generally satisfactory, the yellow arum, white ant, red ant, which were not affected either by the teredo navalis or by the black ant, and when used for piles were never known to decay. In surveying one of the great lagoons, he remarked an old post of lignum vitae in water, about 12 feet below the level of the sea. It was in the shape of a cross, and was said to have been placed there by the natives hundreds of years ago. It was not decayed in the water, and very little affected between wind and water. At the Cape of Good Hope, various methods were adopted for preserving the piles used for the jetty. One method was to lay the piles in water for six months, and then when they were taken out of the water and dried, they were kept in the open air for six months, and before they were put back into water. He was inclined to the opinion that frequent vibration, such as was caused by the passage of trains, acted as a protection against white ants; and he knew an instance in which the timbers of a house were periodically beaten with hammers to keep the ants away. With regard to stone, he had found in the tropics that the
application of linseed oil not only acted as a preservative, but rendered soft stone in the course of a short time so hard that a chisel would scarcely touch it, and that remark applied to imported Caen stone as well as to the chalk stone found in the West Indies. In Jamaica he found the finest grain of marble or good brick, but the material itself was good, and there were buildings which had stood from time immemorial without showing any signs of decay. At the Cape of Good Hope the best mortar was made of shell lime, and, even when very roughly tested, showed wearing qualities. Both there and in India, sun-dried bricks were much used for inferior and cheap building. At the former place there were vineyard walls of sun-dried bricks now standing which were built before the English took possession, the clay being of a tenacious quality.

In the Punjab, however, the clay was very inferior, and soon melted with the rain, so that when the country was flooded, two or three railway bungalows had been seen to fall in a few days. In spite of this, the Kutch-work (or mud-work) was largely adopted. The burnt bricks in the Punjab were mixed with lime, and these bricks were in a sense a preservative, for it is not likely that the material of which the burnt bricks were made has been greatly retarded in its relations to the soil. But the difficulty was being met by making the lower part of the pots of cast iron, into which wooden pots were inserted.

Mr. Todd said that the observations respecting the value of young wood, reminded him of the elaborate experiments that had been made some years ago with chlorides of zinc, sulphate of copper, and other chemical preparations; but in all those cases, the question depended upon the salts which could be absorbed in the soft woods. With regard to the chloride of zinc, it had a remarkable property of amalgamating or uniting with the albuminous matter of the wood, and thus acted as a preservative. He apprehended that by these experiments, the value of the wood for these purposes, by reason of the albuminous or other matter contained as a vehicle for uniting with the preserving material, was established beyond all question.

Mr. J. G. Cockburn Currie said no mention had as yet been made of one of the most useful of all tropical climates which had particularly observed in India. He alluded to the presence and subsequent germination of vegetable matter or seeds in the mortar. When he was employed in the Public Works Department of the Madras Presidency, he found necessary that periodic inspections should be made to guard against this evil. In some instances, where proper precautions had not been taken, roots had formed very rapidly, and of such great size as to bodily dislodge by their pressure large stones from buildings. Mention having been made of the duration of masonry work in India, it might be worth while to refer to the ages of the active masons prior to the period of railway engineering had anything to do with it. A proportion of "Jaggery," or coarse native sugar, varying from about 2 percent in ordinary work to 5 per cent., was part of the work, was time. The technical aspects of the subject had been investigated by some engineers in India, but no very definite conclusions have been arrived at.

Mr. M. Haspall, having been engaged in public works in India, could confirm the statement with regard to "Jaggery" having been used in the mortar, and that the mortar so made set exceedingly well, and was very durable. As the result of his general experience in India, he thought none of the preservative processes for timber which had been mentioned could be compared with that of the "Jaggery" having been used in the mortar, and that the mortar so made set exceedingly well, and was very durable. As the result of his general experience in India, he thought none of the preservative processes for timber which had been mentioned could be compared with that of the "Jaggery" having been used in the mortar, and that the mortar so made set exceedingly well, and was very durable. As the result of his general experience in India, he thought none of the preservative processes for timber which had been mentioned could be compared with that of the "Jaggery" having been used in the mortar, and that the mortar so made set exceedingly well, and was very durable. As the result of his general experience in India, he thought none of the preservative processes for timber which had been mentioned could be compared with that of the "Jaggery" having been used in the mortar, and that the mortar so made set exceedingly well, and was very durable.

The Archaeology of Eastbourne, Sussex.

By the Rev. E. Turner.

The design of this paper is to finish a short account of such objects of archaeological interest as have been discovered from time to time in Eastbourne and its immediate neighbourhood.

I shall commence with a most interesting discovery which was made here in 1805, when, by the fall of a portion of the cliff at or near to the Wish, four Celtic gold bracelets, very similar to those which were discovered four years ago at Mountfield, were brought to light. They were of round form, rather more than 3 oz., and the lightest 16 dwt., and 4 grns. The first was found by a man led to visit the spot by curiosity, and who, not at all knowing its value, took it to Mr. Holt, then a silversmith here, who, to his great astonishment, gave him 23 for it. This led the man to make a further search among the fallen chaff, which resulted in his finding two more, and a fourth was subsequently found. These Mr. Holt also purchased. An examination of the cliff where the slip had taken place was afterwards made, when several bronze instruments were found embedded in it, at a depth of about 10 ft. from the surface. These consisted of three cells of the kind called palstraes, two socketed car, and three lumps of pure copper showing that they must have been lost or hidden there by some native maker of such bronze instruments. This discovery reaching the ears of Sir Joseph Banks, he wrote to Mr. Holt about them, and through them he were exhibited at a meeting of the Society of Antiquaries in London, March 19, 1807, together with the cells and sword, after which Sir Joseph sent them to the museum of them, and they are now in the British Museum, having gone there from the collection of Mr. Payne Knight, in 1836.

Mr. Harvey, of Lewes, has an ancient British gold coin found here.

I shall now proceed to show the claims which Eastbourne has to be considered a Roman station. That it was so clearly proved by the Roman remains which have been discovered in and around it. In 1717, a tesselated pavement of considerable size, a bath, and other indica of these early invaders of this country, were discovered in a field by the seaside, now forming the site of Cavendish-place. The discovery was made by workmen engaged in repairing a post and rail fence. In digging the post-hole, the tool made use of struck upon something that offered a strong resistance, and upon opening a wider space to ascertain what it proceeded from, the Roman pavement was discovered. That eminent physician and antiquary, Dr. Tabor, of Lewes, who drew an account of it, which will be found in the 30th volume of the "Philosophical Transactions," says that the whole field, which measured four acres, is supposed to be full of foundations. The length of the pavement was about 17 ft., and its width about 11 ft. It was constructed of coarse tesselae, with a pavement of brick around it, the whole being very firmly cemented together, as I have already said, the workmen had some difficulty in breaking through it. As Dr. Tabor does not speak of any figures similar to those which so beautifully adorn the Bignor pavement, it was, I presume, quite plain. Other remains of the same people were found here in 1848, by Mr. James Berry, an Eastbourne architect, at a point to the west of the "Sea Houses," and a short distance from Trinity Church, the direction of its massive walls, which varied from 2 ft. to 4 ft. in thickness, and which were constructed of Eastbourne stone, bearing north and south. Mr. Lower, who inspected it soon after it was opened, succeeded with the help of Mr. Berry, in tracing its connection, by means of a corridor, with the bath, passing under the ruins of the town. Besides segments of pavement, of various kinds—black, brown, and red—two coins much corroded, a flint celt, bones and horns of various kinds of animals, tiles of red earth, impressed with a variety of patterns, and a small bronze, were found upon the site. As portions of Pevensey Castle, from which Eastbourne is distant about 4 miles, is the site of Roman Eastbourne, it has been the site of the Roman-British city Andirans where Dr. Tabor claimed for Eastbourne, is now very generally admitted. The Roman remains discovered here were probably the foundations of the villa residence of some Roman officer, high station and command there.

On the Downs, north-west and west of Eastbourne, Roman
THE CIVIL AND MECHANICAL ENGINEER'S SOCIETY.

This Society has now been in active operation for seven years, and our readers will feel interested in its progress. It was formed by a few junior members of the profession in the year 1859, and has since been perseveringly pursuing its aims. It has met with some of the usual difficulties of all new associations, but may now be considered to have attained a permanent position. Until lately the meetings of the society were held at the Freemasons' Tavern, Great Queen Street; but, owing to the rebuilding of that establishment, temporary accommodation has been obtained, but shortly a more suitable and permanent meeting place will be secured.

The council state that the society is intended simply as a medium for the interchange of ideas and information upon engineering subjects, and generally to promote the acquisition of professional knowledge by its members, who for the most part being juniors, feel that they could not, in the earlier stage of their professional course, derive from the older societies the kind of advantages they need, even if they were eligible for membership.

The President for the session 1866-67, just commenced, is Mr. G. Bades Echaces, and the society includes among its honorary members Mr. G. Bades Echaces, F.R.S.; Mr. G. W. Hennem, F.G.S.; Sir Henry James, C.B., F.R.S.; Mr. H. Sinclair; Captain Symonds, R.N.; &c.

At the opening meeting of this session the President delivered an address, some extracts from which we append:—

The properties of materials used in engineering constructions are of two kinds—structural and chemical. Of all materials used, stone is by far the most important, but the great increase in the value of it which has of late taken place, in consequence of the large engineering works in hand, has led men to look about to seek, if possible, some substitute for it. Granite, for instance, is now about 30 per cent. dearer than it was a short time since. Among such substitutes, Mr. Ransome's invention stands out prominently. He has succeeded in producing an artificial stone of a superior kind, which is to be tried on a large scale at Cranston's Hotel, New York, now in 1868. This constructional stone is being built with this material. The character of the materials used for cementing stones and bricks is of almost equal consequence with the stones and bricks themselves. In these cementing materials great improvements have been made, owing to the high requirements of several eminent engineers, and especially the engineers to the Board of Works.

The standard of weight and strength of cements has been so increased as to necessitate corresponding improvements in their manufacture; and, certainly, practical civil engineers will never specify materials which the manufacturer is unable to produce. Iron and steel must continue to increase in favour for engineering purposes, the latter especially giving proofs of such great tensile strain as to make the use of it an absolute necessity; whereas, for instance, in very large bridges it would not be possible to secure the span required if wrought and cast iron, which have less strength, and consequently greater weight, could alone be used upon the work. At present, iron and steel are but little used in the construction of engineering works of other sea defences, though they enter largely into the construction of jetties, piers, &c., but it seems well that they should be employed much more freely in all such constructions, as by the use of them not only would the expense be much diminished, but it would then be possible to imitate similar works in the Mediterranean, where the sea walls are built of iron, leaving the free passage and consequent scouring of the deep water.

A better knowledge of chemistry has been the means of effecting many great improvements in the manufacture of iron. M. Gaudin discovered two ways of producing a very hard iron, one, by adding to the iron a little fluor-iron, and the other by adding phosphate of iron and peroxide of manganese; the metal thus produced he recommended as a material for balls, as being very sonorous.

For supplying London with pure water, and in larger quantities than the present companies are able to do, I consider Mr. Bateman's scheme one of the best. This eminent engineer, in a
The works on the Eastern side would commence with an intermittent conduit tapping the tributaries of the River Louter, and running into an auxiliary reservoir at Springsdale, hence by another conduit tapping the tributaries of the Hawes water, and into this lake, the surface of which would be raised 43 feet.

Another intermittent conduit would carry the water from the Hows Beck, Gill Beck, and Helmondsdale Beck streams into the Hawes water. The water from this lake would then follow the course of the River Louter to a point about 17 miles south of Askham, where a third conduit is placed to convey the water into the River Ramout and the Ullswater Lake. The waters of the Dacre Beck would also be conducted into the Ullswater for means of an intermittent conduit. The waters of the Mosedale Beck, Trout Beck, Barrow Beck, Watendlath and Coldbarrow Falls, would all be intercepted by conduits and conveyed through Thirlmere. The waters of a further area of six square miles would also be conveyed by means of short intercepting conduits and a tunnel under Dunmail Raise Pass into Thirlmere, which would be raised 64 feet.

A compensation reservoir would be constructed on St. John's Beck to receive the waters when Thirlmere is full; such waters are to be given out as compensation to mill-owners on the River Greta. The waters from Thirlmere and Ullswater would be used for the supply of towns, the waters of the River Louter being used for the same purposes. The water from Thirlmere would be conveyed by means of conduit and tunnel to Ullswater, and from the latter the water would be conveyed by conduit and tunnel to Harrow, where a regulating reservoir would be constructed, at a distance of 11 miles from London.

The total cost of this scheme, as estimated by Messrs. Hemans and Hassard, is £11,300,000, and the additional expenditure of £37,000,000, to meet which there would be a probable income of—

From the sale of 50,000,000 gallons daily to towns, &c., on the line of aqueduct, at 3d. per 1,000 gallons £230,125
From the sale of 50,000,000 gallons daily in London for public and trading purposes, at 3d. per 1,000 gallons 136,375
From an average rate of 6d. in the pound on a property of £16,000,000 568,686
£1,051,666

There is also a scheme of Mr. Fulton's which is to be brought forward next session by the existing water companies, who doubtless are reluctant to relinquish their large profits, and finding Mr. Fulton's estimate considerably below those previously mentioned, seem inclined to support it. Mr. Fulton's plan resembles very much that of Mr. Bateman's, but the source is not sought for so far as he proposes to take the supply from a little above Tewkesbury, to which he must divert the sewage of all the towns above that point. And if this is impracticable, he would propose to take the water from the sources of the River Wye. In the latter case the estimate would be about five millions and a half, in the former only three millions.

There is another suggestion, to which I have already referred, from Mr. Gower, with an estimate of £4,328,600, but this appears not likely to be adopted, as being only a partial remedy. This gentleman would not supply soft water for washing, but only for drinking purposes. But, as we have said, a great saving would be effected by the use of soft water for washing purposes, which would be a set-off against the increase in the original outlay, and we may feel certain that no scheme for the water supply of the metropolis will be adopted which does not supply soft water and soft water only. The advantages of which for the channel are even bolder than those for the water supply of London. This communication, however, is less important than the other great measures, which are urgently called for as essential to the cleanliness and well-being of the inhabitants of this vast metropolis; it is, consequently, less likely of a speedy accomplishment, and I shall therefore not take the time of the plans suggested. In the beginning of the present century, before the time of railways, a French engineer, Mr. Mathieu, proposed a tunnel which was designed for ordinary traffic, and was to be lighted by lamps. Among the many other plans subsequently proposed, one of the boldest is that by M. A. Thomas de Gomand. He would connect Eastward, near Dover, with Cape Grisne, at an estimated cost of seven millions. His idea includes the construction of an
island in mid-channel, also subterranean approaches to the
submarine tunnel (that on the English side 9½ miles long, that on
the French side 5 miles long), and two large shafts at either end
de the submarine tunnel, an immense tower being also provided
for access to the island, and for ventilation in the central part
of the tunnel. This scheme was brought forward by Mr. Gamond
about nine years ago, and since then the question seemed to have
been but little mooted until last year, when Mr. George
Remington made the necessary surveys for laying down a line
between Dungeness and Cape Grizney. This route was chosen
by Mr. Remington as avoiding the chalk, which, from his expe-
rience, would render futile any attempt to tunnel between Dover
and Calais. It is certain, however, as that point concerned, it would, in my opinion, be quite possible to tunnel
between those points, and I see no great advantages in the route
suggested by Mr. Remington as compared with the Dover route,
for the object is not to connect England with France alone, but
with the whole continent. As regards the approaches, Dungen-
ness, from its lower level, would be probably more suitable, and
the less amount of water in this route is also a decided advan-
tage. I am not aware that the estimates of Messrs. Remington
and Hawskshaw are definitely given, but they would probably be
about 10 millions. Mr. Remington proposes to construct three
shafts, one at Dungeness, one on the ridge which is crossed by his
lines in mid-channel, and the third at Cape Grizney, in
France.

For the construction of the tunnel, temporary shafts of
wrought iron would be used, and the tunnel would be made
sufficiently wide for two lines of railway, two smaller tunnels
being provided for ventilation, &c. There is not published suf-
ficiently concern ing the construction of the tunnel, but the designs
by this eminent engineer. A bridge across the channel is also
said to have been suggested by Mr. McClean, but of this I can say
nothing. It would, if completed, be more acceptable than a tunnel,
but the expense probably would be nearly double. Pending the execution of these gigantic undertakings, Mr. Fowler’s Channel
Ferry is the readiest remedy, and might be used in the mean-
time.

Military engineering now becomes a part of the civil engineer’s
education, and the successful progress in the manufacture of
large artillery makes it a matter alike interesting and important,
interesting on account of the great experience it gives in the
manufacture and manipulation of the largest masses of metal,
and of the utmost importance, not only because artillery forms the
basis of our national defences, but also because the French and
others, if forced to admit that, notwithstanding all her expec-
ture, England is now, in this respect, behind two, if not three,
other European nations, and these the nations from whom she
would always have most to fear.

The Americans, without doubt, are far ahead of us in the size
of their naval artillery. The Rodman gun, with which many
of their Monitors are armed, could only be successfully
opposed by our 600-pounders, of which we have the good fortune
to possess an unlimited supply in the two disabled specimens,
“Big Bill” and his brother, and a prospect of six or a dozen
others to bear them company in their misfortune. The French
and also unanimously in favour of heavy guns for their fleet, the
ironclad portion of which we must allow to be cast with much
thicker metal than our own ironclads. They have 18 vessels
with a 6-inch coating, and 7 with 8-inch coating, against 3 vessels
of ours, with 6-inch and 1 with an 8-inch coating. The French
seem also to have adopted the plan of casting their large guns,
and it appears that successive in making guns capable of
throwing 150 or 300lb. shot.

The largest cast gun at present employed in the English navy
is the Somerset 100-pounder, the Woolwich authorities seeming
to be bent upon making larger guns, according to some one
or more of the built-up processes. The Armstrong has been
for some years at Woolwich, but, owing to Smith’s failures, this seems about to be finally abandoned for some other
method, and it is to be hoped, for the sake of England’s purse,
credit, and power, that better success will attend the efforts
of the present Government than we have recently seen achieved
in this department, as they succeed to their work instigated by a
long term of repos. Perhaps the principal methods of con-
struction now before the English public, and which may be
briefly mentioned, are (in addition to the well-known Armstrong
the Blakely, the Fraser, the Mackay, the Whitworth, the Palisser,
the Parsons, the new Woolwich, the Ericsson, the Longridge,
the Ames, the Krupp, and the non-recoil gun.

The Blakely system (which includes the Armstrong, Fraser,
and new Woolwich) is, as is well known, founded on the principle
that large iron rings, inflated by means of hoops or rings
shrank on so as to give an external tension and an internal
compression to the material. The Fraser, Armstrong, and Wool-
wich guns differ from the Blakely merely in the construction of
the hoops, or the mode of putting them on, so as to include the
breech.

The Palisser and Parsons guns are constructed on a new
principle, and have for their chief object the making use of the
existing stock of old guns. In these systems a steel tube is
inserted into the bore, and it need not be said that to do this
requires the most careful workmanship, or very uncertain results
will be obtained. The Mackay gun, like the Whitworth, is not
so much a novel construction of gun as a new method of firing,
but the principles of the two systems are exactly opposite.

The Whitworth, aiming at tight, close-fitting shot, would
require to be made according to one of the above-mentioned
methods if made of a large calibre, while the Mackay, having a
very great amount of windage, allows English gunpowder to act
to the slowest degree, under the influence of the Chinese, and
probably by the Americans, for it is scarcely likely that the
Rodman cast guns would stand a full charge of English powder.

The Mackay gun principle, then, is suitable for guns throw-
ing heavy shot, and such guns, on account of the rotation given
to the shot, would excel the Rodman or Somerset smooth bores,
not only in the speed of their shot, but in the amount of work
strengthened on the Blakely system. The Ames gun is purely a wrought
iron gun, made by welding together in succession rings or cross
sections of the gun, and possesses no advantage of initial
tension, but merely of material. As might be expected, it yields beyond
the power of elasticity, so as to become permanently enlarged.

The plan which has been proposed of inserting a steel tube
into the bore would probably prolong the life of such a gun, but
it would thus become a most costly article, and scarcely less
difficult to make than the cast steel guns of Krupp.

There are two other methods of strengthening a tube to form a
steel gun; one is the Ericsson method, which consists in forcing
on to the conical tube discs of iron or steel; but here again, as
in the Blakely, there must be most careful workmanship, other-
wise no satisfactory results can be anticipated. The other plan
is an old one as regards the time of being patented, and has not
yet received the attention it deserves; I allude to the wire
monument system. This, in fact, is the best of the Blakely
system, carried almost to perfection as regards the number
of rings or hoops, but without its disadvantage of requiring
great accuracy of work. In fact, in the wire system a gun can
be made of almost unlimited size or strength, and that, more-
ever, at very much less cost than on any of the other systems.
The limit of the size is not in the material, but in the mere question of facility of use. In this system, where the wire
is wound with a calculated tension on a rough, light casting of
steel or iron, a gun can be made with all the advantages of steel
for the interior, and of steel wire, the very strongest material
known, for the outer portion, and the gun is made in the easiest
manner by winding on the wire. Making small arms is also one of great interest to the engineer, as it is a question of the
best mechanical means to accomplish a definite end, and here again the Americans have gone ahead of us, as
there is little doubt that as effective weapons the Spencer
Henry and other repeaters must be superior to a simple breech-
loading system.

The Atlantic Telegraph now forms the grandest of connecting
links between the old and new worlds. The laying of the cable
of 1857, commenced on the 6th August, when the Niagara
started from Valentia, and on the 6th day, August 11th, the
cable parted with 500 miles to go, and to lay a similar cable the
next year, and, accordingly, on the 25th May, 1858, the Agamemnon and Niagara sailed for an experimental
trip to the Bay of Biscay, their object being to ascertain the practicability of splicing and submerging the cable in mid ocean. The experiments were made in 2,600 fathoms, and having been successful, the expedition left England on the 10th June, 1868, and the splice was made in mid ocean on the 26th of June, but on the same day, after paying out 2½ miles, the cable broke in the machinery, and the splice had again to be made; the laying out proceeded with greater speed until the following day, when the continuity ceased, and on an attempt being made to wind in, the cable broke, and 42 miles of it were lost.

On June 28th, a third attempt was made, and after paying out 142 miles 230 fathoms, the cable again broke close to the stern of the Agamemnon, and the vessels then returned to England.

On the 17th July, the vessels left England, and after some little delay in meeting at the rendezvous, on the 29th the work of paying out commenced; after ten hours paying out the continuity partially ceased, but only for a time; on the return of continuity the laying out was continued until the eighth day, August 6th, when the cable was laid in Trinity Bay, and was in partial working order until September 1st; on that day, however, it finally ceased to transmit the slightest signal. The last message sent from Valentia to Newfoundland was, “Please inform American Government we are now in a position to do best to forward their Government messages to England.” The message subject which will always be the subject that was the last word ever transmitted through the cable. The total number of letters which were sent from August 10th to September 1st, was 21,220. The core of this cable consisted of seven copper wires, surrounded by three coats of gutta percha, then six strands of yarn, and, lastly, eighteen strands of No. 7 iron wire.

Great improvements have since been made in the construction of the cable. The conductor, this year, is the same as it was in 1866, that is, seven wires imbedded in Chatterton's compound. The insulator is also the same as in 1866, four layers of gutta percha, with a coating of paper. The core was protected in 1866 by tin wires, No. 13 gauge, each wire surrounded by five strands of Manila yarn, and the whole wound in spiral form round the core, the latter being padded with jute yarn, which as well as the Manila yarn, was saturated with preservative mixture. In 1866, the same method in the core and the Manila yarn has been used, and, in place of jute yarn, ordinary hemp.

The breaking strain in 1866 was 8 tons 3 cwts., or 12 times its weight in water per knot, as against 11 times in 1866, and less than 5 times in 1868. The means of testing the perfect state of the wires has also been brought to much greater perfection.

The success which has at last crowned the bold undertaking is a cause of sincere congratulation, and the raising of the 1866 cable has formed a double crown for the reward of persevering labour; but we must not rest here, but enquire whether there are not still imperfections in both cables, which can be remedied in the future.

The use of a lighter, and therefore a comparatively stronger cable, seems strongly urged by our experience gained in these late efforts; such, for instance, as that advocated by Mr. Allan, which has a weight of 4½ cwt. per mile, as against 31 cwt. per mile, the weight of the present one. In water, the depth is still more striking, the former weighing 22 cwt. against 142 cwt., the weight of the latter per mile, so that in raising to the surface the strain upon the grappling wire, instead of being for 9 miles of suspended cable a tension of 9 times 142 cwt., or nearly 7 tons, would be only 1½ tons. The raising of a cable on Allan's system increases, the disadvantage of the cable being more durable in deep water, and the laying infinitely safer, and if we continue to apply our thought and experience in this direction we shall have in a very few years the benefit of deep sea cables laid throughout the ocean with as much facility as they are laid in shallow water.

Another point which will probably claim the attention of Engineers is the growing science of aeronautics, which, by means of the Aeronautical Society, seems likely to take a firm hold upon the public. Here young and old are alike inexperienced, and consequently run an equal race in endeavouring to construct a machine which shall be for the air what the locomotive is for the land, and the steamboat for the sea.

In reference to the works completed they are so numerous as to allow a very brief allusion to the most important only. The connection between the London Chatham and Dover Railway and the Metropolitan has been completed, by the opening for traffic of the Blackfriars Railway Bridge, and the Ludgate Hill is now continually crossed by railway carriages. This line places the railways north and south of the Thames in direct communication.

During the past session many important additions to the metropolitan and other lines have been sanctioned by Parliament, one of the most important being the new line to Brighton, which had such a hard struggle in the committee rooms of the Lords and Commons. Many new pneumatic tubes have been or are being laid down, and this system bids fair to become much more general. The Metropolitan, in particular, has been extended with greater economy, as well as to be worked by a much smaller rolling stock; indeed, with little more than actually necessary for carrying the passengers or goods, whereas the heavy locomotives at present in voyage serve rather to draw the heavy carriages than the passengers or goods which they contain. The Thames Embankment has just been magnificently pushed forward, and already many portions of what will be a very handsome wall are unveiled to public view. On the south side the foundations of the new St. Thomas's Hospital are being laid, and this structure, when finished, will form a handsome viaduct to the houses of Parliament. The Cannon Street Station was opened on the 29th instant, and Charing Cross to Cannon Street can hardly yet be said to have got into working order. The widening of Victoria Bridge has been completed from the designs of Sir Charles Fox. The Inner Circle, part of which will run along the Thames Embankment, is rapidly progressing.

Among the important engineering events of the past year is the launch of the Northumberland, upwards of 9,000 tons in weight, after three unsuccessful attempts.

One of the great works of the day, the Forth Bridge, seems to have come to a standstill; and many of the railway companies, owing to a combination of unfortunate events, are at present in a very shaky state. The fact seems to be that while the majority of engineers have been endeavouring to lessen the prime cost of railways by the adoption of the locomotive to steep inclines, some others have constructed lines in the metropolis at such enormous cost, as to render it impossible that they should yield advantageous returns for some time to come. The general body of contractors and engineers have thus received the blame which belongs only to a few of their number, but much more blame is to be attached to those who have made it a necessity for the constructors of railways to obtain loans at enormous rates of interest.

Reflecting upon the difficulties attending the execution of these enormous undertakings, it becomes an important question whether it would not be well for the engineer to subdivide the large works placed under his control, so as to remove the necessity for the acquisition of the limitless tackle and implements, which at present consume the capital and hamper the operations of the contractor.

THE ASOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last monthly meeting of the committee of this Association was held in Manchester, on the 25th September, William Fairbairn, C.E., President, in the chair, when Mr. Fletcher, chief engineer, presented his report, which on that occasion was for two months, since the committee meeting for August had been postponed. Of this report the following is an abstract:

During the last two months 558 engines and 834 boilers have been examined, as well as four of the latter tested by hydraulic pressure. Of the boiler examinations, 684 have been External, 21 Internal, and 529 Entire. In the boilers examined 225 defects have been discovered, 10 of those being dangerous.

Mr. R. F. M. C. O'Neill, Chief Engineer, said that the following steam plant was due to the negligence of the watchman, as most of such cases are. He was getting up steam at five o'clock on Monday morning, when he filled the boiler brimful of water, steam pipes included, and, being alarmed at what he had done, went to call the engineer. Before doing so, however, he had opened the blow-out tap, which he either forgot or could not shut, so that the water was rapidly pouring from the boiler.
all the while, with two brisk fires in the furnaces at the same time. When the engineer arrived the boiler was empty, the fires burning brightly, and the plates of both furnaces overbright and seriously drawn out of shape, while, in addition, the shell of the boiler was rendered so hot, that a piece of wood lying on it was set on fire. The communication of the heat from the furnaces to the shell is an interesting fact; and in another case met with some time since, in which the boiler was without water, similar results followed, and not only were the furnace crowns injured, but the shell of the boiler strained. It has frequently been recommended that the openings in boilers, both for the feed inlet and blow-out, should be above the level of the furnaces; and the adoption of this in the present instance would have saved them. This case is the boiler fitted with a scumming apparatus, but the outlet was carried down to the bottom of the shell, whereas had it been at the surface of the water, although the watchman had left it open the furnace crowns could not have been laid bare. It is true that there must be a tap or valve at the bottom of a boiler for convenience in washing out and emptying, but this should be entrusted solely to the care of the engineer, and the spanner kept under lock and key. Were this simple suggestion generally carried out, the expense and annoyance of injury to furnace crowns through watchmen carelessly emptying boilers would be prevented.

Fracture.—One of these cases occurred at the bottom of an externally-fired boiler immediately over the furnace, the overlap of four of the ring seams being cracked through from the rivet holes to the edge of the plate, and this not at a few holes at a distance one from the other, but at a considerable number, so that the strength of the plate was seriously reduced. This boiler was stayed longitudinally by a flue tube running through it from end to end, which reduced the strain upon these seams of rivets, so that no serious rupture occurred. In the plain cylindrical egg-ended boiler there is no longitudinal strain and hence, when the transverse seams give way, the shell tears in halves. This case is an illustration of the tendency of externally-fired boilers to fail at the ring seams of rivets, and, at the same time, of the advantage of having a longitudinal tie from end to end.

External Corrosion.—This case was met with at the bottom of a new boiler, 7 ft. in diameter, and set on a mid-feather wall 10 inches wide. The corrosion extended from one end of the boiler to the other, just where the plates rested on the brickwork, and the inspector easily knocked a hole through them, and found the thickness not to exceed one-sixteenth of an inch. This shows the object to setting boilers of so large a diameter on mid-feather walls, and the report of the inspectors in which they are retained of ploughing out the brickwork where the transverse seams of rivets rest upon it, so that the condition of the plates may be seen at each inspection. The necessity of a satisfactory examination of this boiler had been for some time pressed upon the owner, and it will be seen that explosion was but narrowly escaped.

Defective Safety-Valve.—The valve referred to was effectively held down by some machinery, temporarily stored over the boiler, which, slipping out of place, rested upon the lever and bent it out of shape. Such a case as this is but rarely met with in the boilers under inspection; but, nevertheless, it shows the value of a defective manhole, which may be referred to. This manhole was unguarded, and fitted with the ordinary internal cover, secured with suspension bolts and bridges, though in a boiler 8 feet in diameter, made of plates three-eights of an inch in thickness, and worked at a pressure of 40 lb. on the square inch. The core of the hole so rotten from corrosion, that the inspector made a breach in it with a hand chisel alone; in addition to which the plate at the edge of the opening was buckled by the pressure of the bridges, and just commencing to rend. It appeared to need little longitudinal strain, and might be given it from an extra turn of the nuts, to force the cover completely into the hole, and thus lead to the explosion of the boiler, as in several similar cases lately reported. On the danger being pointed out,

* This can be accomplished by blowing off from the surface of the water, a plan which is being increasingly adopted, and with good results. If the outlet pipe be carried to the bottom of the boiler, one of the advantages of this system is lost, as in the case referred to in this report.

Explosions.—The Engineer reports that eleven explosions have occurred since the last return, by which 23 persons were killed, as well as 29 others injured. The details of three of these explosions are given. They are of considerable interest, and will confirm the view that steam boilers do not explode for mysterious causes; that cannot be grappled with, but either from neglect in their construction or subsequent working.

No. 35 explosion was due to the gross mal-construction of the boiler, and resulted in the death of two persons and serious injury to seven others. It occurred at the half-way stage on the morning of Saturday, July 28th, at one of two boilers which had but just been laid down for driving a new engine. They were not under the inspection of this Association.

The boiler was of horizontal cylindrical construction, perfectly flat at the front end, and hemispherical at the back, having within it a single horse-shoe shaped flue, both ends of which were attached to the flat plate at the front. It was internally fired, and had no external brickwork flues, the furnace being placed in the left hand leg of the horse-shoe, and the chimney at the end of the right, so that the flames merely passed up over the horse-head and down the importance in those going to the chimney, which was made of wrought-iron, and planted upon a smoke box attached directly to the front end plate of the boiler.

The length of the boiler was about 36 feet, and the diameter 9 feet in the shell, 3 feet 3 inches in the leg of the horse-shoe that contained the furnace, and 2 feet 6 inches in the return flue. The horse-shoe was divided into three-eighths of an inch throughout, with the exception of the flat plate at the front of the boiler, which was fully half an inch. There were two safety-valves loaded to 35 lb. on the square inch, but at the moment of explosion the pressure was a pound or so in excess of this, in consequence of the steam blowing off freely with the horse-shoe flue.

The boiler burst at the flat plate at the front end, which tore away completely from the shell, rending the connecting angle iron through the root. The shell of the boiler was thrown northwards to a distance of about 50 yards, and the horse-shoe flue as far as in an opposite direction, passing in its flight over the pithead gear and a range of four boilers, three of which had steam up at the time, driving another colliery engine. This horse-shoe flue, which was about 33 feet long and weighed about four tons, struck the ground just where the man in charge of this engine had been standing but a moment before, having run through the engine-house and struck the report of the explosion. Had the flue fallen to the ground a few feet short of the distance it did, it would have pitched into the range of boilers just referred to, and, since they had steam up, this must inevitably have led to another explosion. One of them was struck by the funnel of the exploded boiler; but, as it was at work one, but one man was injured, and the other result.

The roof of the engine-house adjoining the exploded boiler, however, was brought down, as well as the side wall and a portion of both end ones, the engineer to the colliery being buried in the ruins, though, fortunately, not killed; while the fireman who was attending to the furnaces was literally blown to pieces, and the engine-house thrown against the fencing round the pit's mouth, and would have fallen down the shaft had it not been guarded. The boiler alongside was lifted from its seat, and blown to a distance of about 50 yards, where it alighted on a public roadway, and had one of its plates staved in by the fall. This boiler was not completed, and five men and a boy were working upon it. Three of them were working outside, and of these one was killed, and the other two seriously scalced and bruised; while two boilermakers and a boy at work inside were carried away with the boiler and rolled over in it, all three being cut and bruised, one of them it serious injuries.

There cannot be the slightest doubt as to the cause of this explosion. The boiler was defective both in design and workmanship. In boilers made with horse-shoe shaped flues, the ends do not receive any support, as they do in those of Lancashire and Cornish construction, from the flue tube running directly through the shell, and thus not only tying the two ends securely together, but at the same time materially lessening the amount of pressure on them by reducing the area on which
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL

November 1, 1866

the steam acts. It is imperative, therefore, that the horse-shoe shaped flue should be secured to the shell by substantial stays, which, however, in the present instance had not been done, and the omission was fatal. The flue tube was merely supported on cradles, and not bound by any longitudinal stay to the shell, while the frame stiffening to the flat plate at the front did not form the most defective. There were five gaps between the furnace, and these were of the roughest workmanship. They did not run back for more than 2 feet, and were attached to the cylindrical portion of the shell with but three rivets, from which, as might have been expected, they tore away. Below the furnace mouth there was not one, nor was there a manhole, which, as well as another in the cylindrical part of the shell, was not strengthened by any mouthpiece. Added to this, the angle-iron attaching the front end plate to the shell, was not welded up into an entire ring, as it should have been, but was in four separate pieces, connected by common jump joints.

This boiler, which had not worked four days before it burst, was designed by the engineer to the colliery, and made on the spot by their own men, as well as the one alongside, which was of very similar and equally dangerous construction, and would inevitably have exploded in the same way as the other had done on being put into the case under the glaring mismanagement, and the lives of the poor men who were killed have simply been lost through the mal-construction of the boiler, the design and workmanship of which were alike defective.

No. 39 Explosion occurred at a quarter past nine o'clock on the morning of Wednesday, August 22nd, to a boiler on board a steam yacht, not under the inspection of this Association. The yacht had been ordered on a cruise, and was just moving out of the dock where it had been lying, when her boiler exploded, killing three persons, as well as injuring others, and seriously damaging the vessel. The engineer was killed on the gunwale, and being being thrown into the water, whence his lifeless body was extricated by drags about an hour afterwards. His wife and another woman on board at the time were both killed, the body of the former being blown to the north end of the lock and her head to the south, while the latter was picked up dead in the forecastle. The vessel was gutted, the deck torn up, the engine, the funnel, as well as the masts and rigging, blown overboard, and pieces of the wreck scattered about the quay in every direction, the boiler being hurled across the basin and thrown to the ground at a distance of 60 to 80 yards, passing over the stern of the vessel in its flight, and a little to the port side of the helm. The boiler, which divided into two pieces, fell in the opposite direction, one part being caught in the forecastle, and the other probably falling into the water, as it could not afterwards be found.

The boiler, which was a new one, having been put on board in January last, and only worked for a few short trips since then, was of very poor workmanship. It was made of iron, and the furnace, of which there were two, running into a flame chamber at the back of the boiler, connected to the smoke box at the front by a number of small return flue tubes passing over the furnace crowns. The shape of the shell was that of a short horizontal cylinder, flat both ends, having a diameter of 6 feet 6 inches, and a length of 5 feet 9 inches. It was worked at a pressure of 90 lb. on the square inch, and had been proved before leaving the maker's yard up to 120 lb. by hydraulic pressure. The flat plate at the back of the boiler was flanged at its entire circumference for attachment to the shell, and consisted of two pieces joined together by a seam of rivets running in a horizontal direction, as nearly as may be through the centre of the circle, the plate being half an inch thick, and strengthened with copper stays seven-eighths of an inch in diameter, about 5 or 6 inches long, screwed throughout, and spaced about 12 inches apart from centre to centre, which, passing through the water space and resting at its depth in the shell, were screwed into the two plates and rivetted over at the ends, just as in the flat sides of a locomotive fire-box.

It was at this end plate that the boiler gave way, tearing round its entire circumference through the root of the flanging, drawing one of the copper stays through the plate, and pulling the other away. In addition, the plate divided at the longitudinal seams of rivets.

Two causes combined to produce this explosion: One, undue pressure of steam; the other, weakness of the boiler. The undue pressure of the steam was due to the defective condition of the safety-valve, which was of lever construction, held down by a Salters' spring balance. I am not able to speak of the condition of the safety-valve from a personal examination, since it had been taken to pieces before I saw it; but the captain of the yacht, examined at the request that the engineer was in the habit of raising the lever of the safety-valve by hand, and then allowing it to stick, and that he had done this about five minutes before the explosion; while a master boiler maker, who made an official investigation at the order of the coroner, reported that he did not find the valve in free working order; and this was corroborated by the maker, who examined it but half an hour after the explosion had occurred. It was evident that the equipment of this boiler that there was but one safety-valve, whereas there should always be a duplicate. A Select Committee of the House of Commons, appointed in the year 1817, to consider the best means for preventing the explosion of boilers on board steam vessels, recommended "that every such boiler should be provided with two sufficient safety valves;" while this recommendation was repeated in America, in the year 1836, by a committee of the Franklin Institute, 'appointed to examine into the causes of the explosions of boilers used on board steam-boats,' and the Board of Trade now enforce that no British steam vessel can be put into passenger service unless two valves can be complied with. Had the boiler under consideration been on board a passenger vessel instead of a gentleman's pleasure yacht, it would not have been allowed to put to sea equipped as it was with but one safety-valve. The other cause of the explosion—viz., the weakness of the boiler—was due to the insufficient size of the flues flat ends being but about 3 feet in length, with such an area as to impart, with steam at a pressure of 90 lb. on the square inch, the heat to a strain of nearly four tons each, which, since they were made of copper, and only seven-eighths of an inch in diameter at the outer edge of the threads—was dangerously near to their ultimate strength, and allowed but little margin either for indirect strains by the weight of the water or for flaws in the metal, so that to rend these stays asunder there was required but a slight addition to the ordinary working pressure of the steam, and this appears to have been produced by the sticking of the safety-valve referred to above. The boiler should have been made either more or larger in diameter; but as it was they were insufficient, and the explosion is attributed to the combined defects in the equipment and construction of the boiler.

No. 45 explosion has excited considerable interest on account of the fact that it had occurred at one of Her Majesty's dockyards. It took place at about half-past ten on the morning of Friday, September the 7th, and resulted in the death of two persons, as well as in injury to three others.

I visited the scene of the catastrophe a few days after the explosion had occurred, and received every assistance from the authorities of the dockyard in making my examination. I am flat. The primary cause appears to have been a longitudinal one, the stays asunder, which in addition to the plate divided at the longitudinal seams of rivets.
THE RAILWAY SYSTEM OF GERMANY.*

By Robert Crawford.

There are few subjects which afford more varied and interesting questions for consideration than the growth and development of railways. Whether viewed with regard to the gigantic embrace which they have assumed, or to the increasing needs of nations, or their beneficial effect in promoting the introduction of improvements in machinery and manufactures, they cannot fail to present abundant matter for examination and reflection. Nor can an outline of their progress within fixed territorial limits be without some value, in furnishing and grouping together the elements of information, which may aid in the formation of correct opinions, as to the advantages and defects of certain systems.

It is in this latter respect that Germany has been selected as the field of investigation for this paper, since, although in the first instance railways were there adopted with reserve and caution, their construction was afterwards prosecuted with considerable steadiness of purpose, and with but slight fluctuations in the regularity of their progress, except such as arose from political questions, or state policy. In Germany, as in England, tramways formed the germ from which subsequent enterprise developed the vast network of railways extending throughout the length and breadth of the land, facilitating its commerce, and increasing in no small degree its material prosperity and wealth.

The oldest of these undertakings originated in a fifty years' privilege granted by the Austrian Government, upon the 7th September, 1824, for the construction of a line from Budweis, in Bohemia, to Oppolitz, a distance of upwards of 80 English miles. In the beginning of the year 1825, this concession was transferred to a Joint-stock Company, formed in Vienna, under the title of 'The Imperial Royal First Railway Company of Austria.' The works were immediately begun, and about 40 miles finished before the close of 1826. The completion of the remainder occupied until the 1st August, 1833, the day of the opening of the line throughout its entire length. About this time a new project was set on foot, and a concession granted to an association of business firms in Vienna, for a line from Linz to Gmunden (434 miles), which was made over, in 1834, to the Budweis and Linz Company. The works were begun in the same year, and finished in 1836. This line, although claiming the name of railway, was in reality a tramway, worked by horses. The gauge was 3 feet 7½ inches in the clear. The rails consisted of flat bars of iron, 3½ inches wide by rather more than 1 inch in thickness, and weighed 144 lbs. per yard; they were laid on longitudinal timbers, supported and kept in place by cross sleepers, 6 feet 3 inches apart from centre to centre. The maximum gradients were 1 in 20 on the length between Budweis and Linz, and 1 in 46 between Linz and Gmunden.

The junction of the northern and southern sections was affected by means of a short line, on which occur gradients of 1 in 15 and 1 in 28, passing over the Danube on the timber bridge between Linz and the north shore of the river, which answers for the purposes of ordinary traffic as well as for those of the tramway. The cost of the Budweis, Linz and Gmunden line was about £4,877 per mile. In 1854, small locomotive engines were adopted for the working of a portion of the southern section, and this system was extended in the following year to the entire length between Linz and Gmunden. The gauge remained the same, but the permanent way was altered on the inclines and sharp curves: the original flat bars and longitudinal timbers having been replaced by small solid rails of the commonest description, and broad-based wooden sleepers. While the above system was in course of construction, and before it was completed, a different form of railway was evolved, which it is proposed to call the ordinary railways, with the regular minimum gauge of 4 feet 8½ inches.

Returning from the digression occasioned by tracing down to a recent period the salient points in the history of what was not only the first line in Austria, but in all Germany, the enterprise which next attracts attention is that of a proposal for connecting

* Read before the Institution of Civil Engineers.
Prague with Pilsen, by means similar to those already described. The works were begun in 1828, and a portion of the line was opened in 1830. The original project was never completed, and a length of 341 miles of tramway, the extent to which it was carried into execution, after changing ownership twice, was finally made over to a Colliery Company for local purposes.

The results of the experiments made on the subject of the most important and decisive period in its history, occasioned by the proposal to adopt steam as a motive power instead of horse labour; a proposition carried into effect for the first time in Germany in the case of a railway 4 miles in length from Nürnberg to Fürth, which was opened for public traffic on the 7th December, 1835. The works on this line were unimportant, and presented no engineering difficulties whatever, occupying only nine months in their construction. The cost was £4,743 per mile. The rails, which were for a single way, were laid for about three-fourths of the distance on stone blocks, and the remainder on timber sleepers, which were subsequently replaced by stone supports. The maximum gradient was 1 in 250.

Thus Germany, possessing, at the close of the year 1835, upwards of 108 miles of tramways, had up to the same time only 4 miles of railway, properly so called.

The five years following in regular succession from this date served to introduce railways into all parts of the country, and to give them a fair start. It appears that upon the 31st December, 1840, five years after the completion of the first line, there were twelve railways in Germany, either wholly or in part finished, and yielding a total length opened, equivalent to 377 miles. These, arranged according to the priority of opening of any part of them, and given in the following order, being promised, that those lines worked by steam power are alone referred to:

1st, Railway in Germany from Nürnberg to Fürth opened 7th Dec. 1835  
2nd, " Leipzig to Dresden, a portion was opened 24th Apr. 1837  
3rd, " Vienna to Oderberg " 23rd Nov. 1837  
4th, " Berlin to Potsdam 22nd Sept. 1838  
5th, " Düsseldorf to Elberfeld " 15th Oct. 1838  
6th, " Brunswick to Wolfsbüttel " 1st Dec. 1838  
7th, " Magdeburg to Leipzig " 29th June 1839  
8th, " Cologne to the Belgian frontier 2nd Aug. 1839  
9th, " Munich to Augsburg 1st Sept. 1839  
10th, " Frankfurt-on-Main to Wiesbaden 26th Sept. 1839  
11th, " Berlin to Anhalt " 1st Sept. 1840  
12th, " Mannheim to Heidelberg " 12th Sept. 1840  

Such was the position of railways at the close of the year 1840, after which they became so numerous and varied that it would be impossible, keeping in view the object of this paper, to follow them any further in detail. It is sufficient for the present purpose to review in general terms their progress from time to time, from their first adoption down to the present day, as exhibited in the following statement, showing the extent opened at different fixed periods:

<table>
<thead>
<tr>
<th>Year</th>
<th>Length (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1835</td>
<td>377</td>
</tr>
<tr>
<td>1836</td>
<td>1,817</td>
</tr>
<tr>
<td>1837</td>
<td>4,487</td>
</tr>
<tr>
<td>1838</td>
<td>4,760</td>
</tr>
<tr>
<td>1839</td>
<td>8,612</td>
</tr>
<tr>
<td>1840</td>
<td>88,666</td>
</tr>
</tbody>
</table>

The local distribution of this latter quantity and the cost per mile are as follows:

In Prussia there were about 3,417 miles constructed at an average cost per mile of £16,200. In the German provinces of Austria 1,708 were 22,700. In Bavaria 1,172 were 13,670. In Hanover 450 were 13,100. In Saxony 435 were 18,350. In Hessen 260 were 16,500. In Württemberg 1,465 were 14,500. In the other German States 1,168 were 14,590.

Total 8,886 miles constructed, at an average cost of about £16,400 per mile.

Nearly one-fourth of the entire length is provided with two lines of rails.

About 36 per cent. of the existing lines are Government property. 10 are the property of Companies, but worked by Government. 61 are the property of, and are worked by private, or Joint Stock Companies.

Many railways which were originally constructed by State means have been sold, or rented to Joint Stock Companies, and the reverse of this has in some instances taken place. Hence it becomes necessary to return to an examination of the manner in which they were at first carried out, in order to estimate the extent to which Government resources participated in these undertakings. In this respect it appears:

39 per cent. of the entire length were constructed by different States. 24 by Companies under a guarantee of interest, or a Government subscription.

36 at their own risk and cost.

That is to say, Government aid has been granted directly, or indirectly, to nearly two-thirds of the entire system. These railways comprise sixty-two different undertakings, as at present constituted, under as many separate organisations, and are managed by nineteen Government departments, and forty-three boards of Directors, or some substitute, whose control however is not confined to Germany proper, but extends to adjoining territories, over an aggregate length of 10,580 miles of line.

Not long after the introduction of railways in Germany, it became apparent, that their management would be far from sufficiently perfect to meet the continually increasing requirements of commerce, except some common plan of action could be agreed upon, which would bring all the railways in the country into one legal association, for regulating to a certain extent, their relations with each other, according to general rules, somewhat after the manner of the German political Confederation. For this purpose a conference was held at Cologne, in June, 1847, which resulted in the formation of a society under the title of "The Association of German Railway Directions" which now embraces the whole of the lines already referred to, with very trivial and unimportant exceptions. Each railway subscribes a fixed sum towards the general management fund together with a variable amount depending upon its length, and is represented at the meetings of the Association and in the debates, in proportion to its importance. Yearly general meetings are held, at a time and place mutually agreed upon, and when considered expedient, special meetings are also called. All at these, such matters as relate to the interests of the Association are discussed and settled. A code of laws has been drawn up, and agreed to, by the Engineers and managing directors present at these meetings, which is revised and enlarged from time to time, according to the requirements. These rules express the decided opinion of the associated body, upon all the points which are usually involved in the construction and working of railways, and are adopted by all concerned, as the standard source of guidance and instruction in such matters. It may here be proper, before passing on to the consideration of the engineering points involved in the preservation of the associations, to state that Germany at the close of the year 1861, had, in addition to railways, about 143 miles of tramways, constructed at an average cost of £3,200 per mile.

The battle of the gauges can scarcely be said to have been fought in Germany, or, if so, it was conducted with almost all the energy on one side; as, early in the movement, the gauge of 4 feet 8½ inches came off victorious, and the line from Mannheim to Heidelberg, which represented the opposing interest, having been laid to a medium width of 6 feet 3 inches between the rails, after struggling along for some time in its unsocial loneliness, was obliged to yield under the pressure of opinion and the inconvenience arising from a break of gauge, and was altered to the ordinary width of 4 feet 8½ inches, which is now the universal gauge of the country. The width between the ways on a double line of railway is usually fixed at 2 metres between the centres of the rails, or 6 feet 4 inches in the clear. At this allowance on all ways in mountainous countries, to be diminished in exceptional cases, where necessary, to 6 feet, but never less.

* To this must be mentioned as an exception the branch from Lambach to Gmunden, 16 miles in length, already described.
Secondly. The general scale of maximum gradients admissible on railways is 1 in 200 in level districts, 1 in 100 among hills, and 1 in 40 on mountain lines.

As examples of sharp curves upon works already executed may be given—One of 670 feet, and another of 590 feet radius on the Baden State Railways; two curves of 618 feet radius on the railway from Magdeburg to Wittenburg, and a similar minimum radius on the railway from Breslau to Schweidnitz; one of 560 feet and several of 622 feet radius occurring on the passage of the Alps, on the line from Vienna to Trieste; the viaduct approached to the Cologne bridge, on the left bank of the Rhine, is on a curve of 618 feet radius of a length of 750 feet radius on the line between Passau and the Austrian frontiers, and of 924 feet as the minimum radius of curvature on the Main Weser Railway, from Frankfort-on-Maine to Hesse Cassel; besides numerous other curves of importance on existing lines.

With the progress of locomotive engines has introduced into practice a severer character of ruling gradients than was formerly contemplated. On main lines, when practicable, 1 in 100 is now generally adopted as the maximum rate of inclination. In many instances, where the districts traversed are very level, the gradients are much easier than this; but, on the other hand, there has been a great deal of having adopted the limits recognised at present as suitable for the working of locomotives, in gradients of the steepest description, which are not confined to one state or locality, but are to be found in both north and south. As an illustration of this statement, it will suffice to instance some of the most important cases. Between the points of Brakel and Neukirch, on the line from Dusseldorf to Elberfeld, there occurs a continuous incline of 1 in 30 for a distance of 8,038 feet, or upwards of 1½ mile. This was originally worked by stationary engines and a long endless rope. In 1841 the plan was altered, and the trains in opposite directions arranged so as always to meet at this point, and the weight of the descending trains, two curves of 622 feet radius, and made use of to help in drawing the other up by means of a rope attached to both trains, and passed round rollers at the top of the incline. The difficulties arising from the necessity for the meeting of trains brought about another modification in the system of working, which is now in use. A pilot engine is always ready, with steam up, to assist the ascending trains, which it does by acting as a counterpoise attached to the upper portion of the rope, in the same capacity as was formerly fulfilled by the descending train. This latter now always passes down without being attached to the rope, and under the control of powerful breaks, and by these means the inconvenience of the traffic, from being compelled to descend with trains held up, has been removed. The Aix-la-Chapelle incline of 1 in 38, for a length of 6,814 feet, stands next on the list. It begins immediately on leaving the station, and rises westwards towards the Belgian frontier. It, also, was intended to be worked by stationary engines, but a tank engine, with three pairs of coupled wheels of small diameter, now and for the purpose of pulling through from behind, reduced the incline to the station at the level on the summit, where an ordinary engine is in waiting to take the train on. Several gradients of 1 in 40 and 1 in 45 were adopted on the Semmerring Railway, of which a particular account has already been brought before the Institution. An incline of 1 in 40, for a distance of 17,980 feet, or upwards of 5½ miles, upon the Bavarian State Railway, from Augsburg to Hof, serves to surmount the water-sided between the rivers Maine and Saale, near the village of Neuenmarkt. The short Schneeberg branch line in Saxony has gradients of 1 in 40, and the total ascent which it makes averages at the rate of 1 in 48. The passage of the Swabian Alps, between Geisingen and Amstetten, on the Würtemberg State Railway, from Stuttgart to Ulm, is accomplished by means of an incline of 1 in 45, 16,720 feet long, or 5½ miles. There is a gradient of 1 in 45, for a length of about 1,860 feet, at Vienenburg, on the Brunswick State Railway, from Wolfenbuttel to Hanover. On the railway from Bamberg to Aschaffenburg there is a gradient of 1 in 45, 41 miles in length. The same rate of inclination occurs on the line from Breslau to Schweidnitz, and also between Eisenach and Coburg, near the former place, on the Werra Railway, the length of the gradient being 3 miles.

The Semmerring Railway, already alluded to, is one of the most remarkable instances of the use of high gradients with sharp curves. This line, which is in reality but a section of the Southern Railway of Austria, from Vienna to Trieste, extends from the station of Gloggnitz to that of Murzuschlag, a distance of 26½ miles, or more exactly 134,300 feet. In considering the nature of the gradients, it may be divided into three sections as follows:—

1st from Gloggnitz to Payerbach 26,815 feet.
2nd , Payerbach to the Semmerring summit 61,033 feet.
3rd , the summit to Murzuschlag 48,462 feet.

Total 131,300 feet.

In going southwards the rise is gradual until Payerbach is reached, the maximum inclination being 1 in 100. From thence, until attaining the summit level, which gives its name to the pass, the gradients and curves are of the hardest and sharpest character, in order to overcome the various natural obstacles in the way. On this middle section several gradients of 1 in 40, one of them, the longest on the line, being 11,618 feet, or 2½ miles, and curves of 622 feet radius occur. From the summit to Murzuschlag station the descent is rapid and steep, the heaviest rate being 1 in 41½. The difference of level between Gloggnitz and the summit is 1,606 feet; the height of the latter being 2,937 feet above the sea-level; and the fall from thence to Murzuschlag on the South side is 714 feet. The nature of the inclines, and their effect upon the working of the line, will be best understood by referring to the following tabular statement:—

<table>
<thead>
<tr>
<th>List of Gradients</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 1 in 40 to 1 in 50</td>
</tr>
<tr>
<td>1 in 51 to 1 in 70</td>
</tr>
<tr>
<td>1 in 71 to 1 in 100</td>
</tr>
<tr>
<td>1 in 101 to 1 in 200</td>
</tr>
<tr>
<td>Level</td>
</tr>
</tbody>
</table>

The curves under 1,000 feet radius are,

<table>
<thead>
<tr>
<th>Curve of 560 feet radius.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in 46</td>
</tr>
<tr>
<td>1 in 47</td>
</tr>
<tr>
<td>1 in 52</td>
</tr>
<tr>
<td>1 in 59</td>
</tr>
</tbody>
</table>

The proportion of straight line and curves stands thus,

| Curve of 560 feet radius | 0 per cent. of the entire length. |
|--------------------------|
| 622 | 10 |
| 623 to 1244 | 26 |
| 1246 to 1857 | 6 |
| Over 1867 | 0 |
| Straight line | 50 |
| Total | 100 |

Several of the curves of 622 feet radius occur upon inclines of 1 in 45.

There are fifteen tunnels on this work, of the aggregate length of 14,807 feet. The longest is that through the summit, called the Semmerring, which is 4,986 feet. The next, in point of length, is one of 2,280 feet.

The viaducts, of which there are sixteen, are built of masonry and brickwork, and are principally composed of semicircular arches, varying in span from about 25 feet to 65 feet. The longest of these works is 614 feet, and the four which attain to the greatest height, from 119 to 160 feet, consist of two rows of arches, one above the other; the lower of which tends to strengthen the piers and add stability to the structure. Many of the viaducts are placed on curves of 622 feet and 933 feet radius, and on gradients of 1 in 45.

The permanent way consists of flat-based rails weighing 70½ lb. per yard, resting on cross-sleepers, laid 3 feet 11 inch apart from centre to centre, which in their turn are supported by longitudinal timbers, into which they are let, and held firmly in place by small angular iron brackets. The rails are 4¾ inches in depth, have a similar width of base, with a head 2½ inches broad, and a thickness of 3½ inch for the central web; their usual length being 18 feet 8 inches. The joints are made fast by fish plates, with four screws-bolts in the usual manner; underneath are placed wrought-iron chair-plates, to prevent the working of the ends of the rails into the sleepers. A similar joint to this, but of smaller dimensions, is interposed between the base of the rail and the timber at each, of the intermediate bearings. The joint sleepers are 12½ inches wide, by 66 inches thick, and the intermediate sleepers are 9 inches by 60 inches. The ballast
consists of a lower course of angular broken stone of large dimensions, laid with the hand, on which rest smaller broken stone and gravel. Its depth at the centre of the gauge, measured from the surface of the "boxing," which reaches to within 2 inches of the rail level, is 2 feet 4 inches, and the width to which it extends outside the rails is 4 feet 6 inches on embankments, and 3 feet 9 inches in cuttings.

The engines used for working the line are of a peculiar description, the result of a prize offered by the Government, for the best locomotive to take a given load up the inclines, with a fixed minimum velocity. The engine and tender are in one, and rest upon five pairs of wheels; the three leading pairs are coupled together, and attached to axles fixed at right angles to the axis of the boiler. The other two axles are placed, one in front of the fire-box, and the other under the tender, and are attached to a moveable carriage, or frame, which admits of the wheels suiting themselves to the nature of the sharp curves to be traversed. The following statement shows the comparison between the passenger and goods engines on this line, and their principal average dimensions:

<table>
<thead>
<tr>
<th>Passenger Engine</th>
<th>Goods Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of Driving-wheels (3 pairs coupled)</td>
<td>Ft. in.</td>
</tr>
<tr>
<td>Diameter of uncoupled wheels (2 pairs)</td>
<td>4 3</td>
</tr>
<tr>
<td>Diameter of cylinder</td>
<td>3 1</td>
</tr>
<tr>
<td>Length of Stroke of Piston</td>
<td>1 6½</td>
</tr>
<tr>
<td>Diameter of Boiler</td>
<td>2 0</td>
</tr>
<tr>
<td>Length of boiler</td>
<td>4 3</td>
</tr>
<tr>
<td>Number of Tubs in boiler, ft. in.</td>
<td>No. 191</td>
</tr>
<tr>
<td>Average Heating Surface in sq. ft.</td>
<td>1,694</td>
</tr>
<tr>
<td>Maximum pressure of steam in boiler, per square inch</td>
<td>100 lbs.</td>
</tr>
<tr>
<td>Thickness of Iron Plates in Boiler</td>
<td>½ in.</td>
</tr>
<tr>
<td>Distance apart of centres of extreme coupled wheels</td>
<td>8 11½</td>
</tr>
<tr>
<td>Ditto, uncoupled about</td>
<td>8 0</td>
</tr>
<tr>
<td>Total length of Engine from buffer to buffer</td>
<td>37 11</td>
</tr>
<tr>
<td>Total weight of Engine on 5 pairs of wheels (empty)</td>
<td>30 tons.</td>
</tr>
<tr>
<td>Adhesive weight of Engine on 3 pairs coupled wheels, loaded with an average supply of water, &amp;c.</td>
<td>44 tons.</td>
</tr>
</tbody>
</table>

The cost of one such engine was about £3,500.

The experience derived from the working of this line goes to show that, one of the goods engines can ascend the inclines of 1 in 40 at the rate of 9½ miles per hour, working with it a goods train, whose gross weight is from about 100 tons to 105 tons, according to the state of the rails and the weather at the time. The normal rate of speed fixed is as follows:

- Ascending: 14½ miles per hour.
- Descending: 14½ miles per hour.

" Ordinary Passenger" ditto 11½ " 14½ "
" Military Transport and Goods Trains " 9½ " 9½ "

In case of a train being late, any one of the foregoing speeds may be increased, if necessary, by 4½ miles per hour. The maximum number of trains which have passed over the line in one day occurred during the Italian war, and amounted to seventy-two. The ordinary average daily number of trains is twenty-seven, with from seven to eight carriages in each train. The actual works of construction on the Semmerring Railway were begun towards the close of the year 1848, and the line was opened for public traffic on the 17th July, 1854. Previous to this, however, during the year 1849, the rails were laid throughout the entire length of the line, and goods were transported over it by means of locomotives. The line, which is laid with a double way throughout, cost £98,720 per mile.

The Foundations of the Old Louvre.—Excavations have recently been made in the court of the Louvre, with the view to discovering the real position of the older Louvre, that of Philippe Auguste, but the work has met with a partial success. The foundations of the walls of the whole of the five towers of the former building. These ancient works are very solid, and are now in part open to the view of all the world.

THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

THE INSTITUTION OF CIVIL ENGINEERS.

paid directly for the smoke, living where it prevailed, and that the middle classes and the wealthy suffered proportionately in being compelled to live out of town, and to spend time in going to and fro. Dr. Smith remarked that it was quite true that carbon, tar, and sulphuric acids were disinfectants; but we did not find them burning out of the steam boilers employed in our large factories are very different.

1st. Because coals are constantly being added to the mass in combustion. There is not, consequently, that cessation of the distillation of tarry products above stated, as taking place in the fireplace of private dwellings, and it follows that the products of perfect combustion, such as carbon dioxide and water, do not pass like those of the fireplaces in factory furnaces, are constantly mixed with a considerable quantity of tarry substances produced by the distillation of the coals, and, therefore, through their imperfect combustion.

2nd. As stated above, in the chimneys of our dwellings, the draught is such as to permit many of the imperfect products of combustion, or most of the tarry products, to condense, whilst in the tall chimneys erected in our factories the draught is such as to carry out from them the above noxious volatile products; and as many of them will easily condense into liquids and solids when they come into contact with a cold atmosphere, therefore they cannot diffuse nor spread far before they fall upon plants and other bodies existing in the neighbourhood of such chimneys, and as many of the tarry products are highly poisonous to plants, they affect vegetation in a very marked manner.

3rd. "Black smoke" is a mixture of the products of the imperfect combustion of the solid particles of carbon when floating in the atmosphere become, like all solids, centres of attraction for fluids, and thereby assist in the condensation of the liquid and poisonous products above mentioned, and help to carry and fix them on the surrounding vegetation, which is characterised by a deposit of such products upon the surface of the leaves and stems of plants, which prevents that free contact with the elements of the atmosphere which is so essential to their health and growth; for, as you are aware, plants absorb carbonic acid from the atmosphere from which their carbon is derived, and they reject oxygen and watery vapour. Further the intensity of these actions is in exact ratio with the intensity of light, and when "black smoke" is produced in large quantities it interferes with the rays of light arriving on the surface of the earth, and thereby affects vegetation materially. It appears to me that the above facts give an explanation of the activity of vegetation observed in London as compared with that witnessed in Manchester or any other manufacturing town. We are all aware that the vegetation in these towns may be slightly affected by the large proportion of sulphuric acid which the smoke issuing from the factory chimneys contains as compared with the quantity of sulphuric acid produced by the consumption of a better class of coal in London, but sulphuric acid, like all acid products, is less injurious to vegetation; it is not so much as the air with which it mingles is so considerable, owing to the high temperature at which it leaves the top of the high chimneys, that although it may somewhat affect vegetation, still I consider its action is comparatively small in proportion to the injury effected by the fixation of "black smoke" on the plants, as described above.

As to the comfort which the inhabitants of our large manufacturing towns would derive from the perfect combustion of the fuel in our large mills, works, &c, no one can venture to say; at all events, as a matter of health and comfort, an opinion can be formed by comparing the state of the atmosphere in large manufacturing towns like Manchester with that which is witnessed on the other days of the week. It is hardly necessary to add that it is on record in evidence before a Committee of the House of Commons that manufacturers can effect a saving of 15 or 20 per cent. by burning their smoke, and it is most painful to reflect that after the weighty evidence which has been adduced to the House by Messrs. Bazley, J. Whitworth, Henry Holdsworth, &c., before a Committee of the House of Commons some twenty years ago, we should still live in such a noisome, unwholesome atmosphere as that of this city; and, lastly, to witness how Acts of Parliament are put on one side, when they are not to be much; and enforced by local authorities who are in such cases the offenders, and at the same time the authorities called upon to inflict fines and punishment.

Mr. Peter Spence, F.C.S., read a paper on the same subject, in
ON THE UTILIZATION OF METROPOLITAN RAILWAY ARCHES AS DWELLINGS.*

By B. Emanuel, C.E.

The want of good and sufficient accommodation for the labouring classes in the metropolis has been felt more within the last few years than at any other previous time, and has at length attracted public attention to the means for its redress. It is unquestionable that the evil has been caused to a great extent by recent metropolitan engineering works, and particularly by railway extensions. It is estimated that 20,000 people have already been evicted, while 100,000 more will be dispossessed by the various schemes now on foot. No further argument than this statement is needed, to prove the necessity for prompt action.

While it is clear that such a scheme is the best which, if capable of being practically carried out, would make the cause of the evil the means of its removal, it follows that no such perfect scheme can be devised as the one which would make it the interest of the railway companies (which turn out the poor wholesale) to find means for their accommodation.

To compel railways, by direct legislative interference, to give house-room to the poorer classes whom they evict, would be impracticable. The principle has already been attempted to be enforced and it has signally failed. As matters stand at present and with the strong opposition which railway companies can raise in Parliament to an unsalable scheme, it is a matter both of policy and of necessity to endeavour to adopt other than compulsory measures. If, then, a feasible scheme could be shown by which the railway companies would increase their revenues, the poor would be removed, and the interest of the railway companies would be, not to oppose, but perhaps to further that scheme.

In and about London there are thousands of railway arches belonging to the various companies. Some few of these are used as shops, a few more as warehouses and workshops; but the great majority of them are, at the present moment, totally unoccupied and unproductive.

To convert these existing arches into labourers’ dwellings, and to provide for similar accommodation in all former viaducts built in the neighbourhood of great cities, will at least provide for a large proportion of those now ejected.

It is the object of this paper to discuss the means which can be taken to best carry out this scheme, and the advantages or otherwise arising from its adoption.

For each dwelling that is built inside a railway arch, two side walls will be sufficient to support the roof and to contain the earth. It will immediately suggest itself that an advantage is gained in point of economy of construction over the same amount of accommodation anywhere else; and this saving may be calculated at about £80 each arch, or £25 per room.

It may be urged in opposition to the idea itself, that tenants could not be obtained for this class of dwelling—that the noise and vibration arising from the traffic overhead would render such arches practically uninhabitable. It is believed that this objection, though popular, is groundless. A very few of these arches are fitted up and occupied as dwelling-houses, and the author during the investigation of the past few months into this subject has met with and questioned the occupants of most of these—the experience of some ranging over a period of six years. They have been unanimous in the statement that no great inconvenience is experienced. Indeed it is a fact that the noise and vibration arising from the passing trains is more felt in the houses by the side of the railway than in the arches themselves; and if further evidence be required it is possible to point to shop restaurants, &c., where business is carried on with no more disadvantages than if the premises were streets distant from the railway.

It may be a matter of surprise that such an obvious expedient as the utilization of the arches should not have been previously carried into effect. It is probable that had they been proposed on a large scale, and the great number of individuals they would since have been so utilized. But although the idea has, doubtless, been suggested before, and notwithstanding the difficulty of dealing with any new idea by a railway company, other causes have had their effect in delaying the scheme. The causes which have prevented private individuals from taking the arches from the companies and converting them as proposed, are somewhat numerous; but, as will be seen, are matters of practical detail only.

One of the most important preventive causes is the policy of the companies, hitherto, in refusing to grant long leases. Many of them give only a yearly lease, and then for a term as short as 14, or 21 years—while all insert clauses reserving power to retain possession by a three or six months’ notice.

This policy, if persisted in, would be fatal, for it would prevent capital being employed by private individuals on such a precarious tenure. But as possession is only likely to be again required by the companies in case of a danger of eviction, it is possible that such meet the requirements if a short lease only were granted, and compensation be given in case of eviction, for the money laid out in fitting the arches as dwellings.

Again, the present leases vary a great deal in size, and, therefore, indemnity is given to the purpose. The best type is an arch about 25 ft. by 15 ft. in height, 9 ft. from the ground to the roof, and 6 ft. deep. In each of these arches could be built five rooms, a washhouse, yard, and offices. But only a small proportion of the whole number of arches closely approach this type. In the construction of a railway viaduct, the requirement insisted on by Parliament is a headway of about 17 ft. where the arches of the viaduct cross public roads. For purposes of economy, the height of the arches is reduced directly the roadway is passed. The consequence is that the generality of arches do not average nearly 20 ft. in height. Those on the London, Chatham, and Dover extension system average only about 14 ft. from the ground to crown of arch.

Again, there are also many arches under four lines of rail, where a necessary depth of about 50 feet for this purpose would render them too closely approaching tunnels, for the light and ventilation essential to a dwelling-house. Though then a double dwelling-house can be constructed, with six rooms in each arch, it is obvious that, where the railway as the London, Chatham, and Dover, yet the accommodation in point of economy of building, of light, and of ventilation, would not be perfect. It is necessary to add, however, that a very large number of arches of the latter type are at present in existence round London.

Again, it may be objected that the smoke arising from the arches would be likely to do great injury to the passengers on the railway. The few chimneys which now exist without complaint are at the level only of the top of the parapet; but, if future inconvenience be experienced, it will be a slight matter to carry the chimneys up to above the level of the carriage tops.
If this is found to be ineffectual, it will be possible to use one of the numerous smoke-consuming grates or stoves, or the principle (which has been carried out in some of the buildings of the Metropolitan Association for Improving the Dwellings of the Industrial Classes) of conveying the smoke from a number of flues into one large common shaft, may be applied. In any one of these ways it is possible to obviate any objections on this head.

The difficulty of access to some, and the absence of water-pipes and drainage, have also hitherto acted as a slight drawback to the adoption of arches as dwelling-houses.

The above are the principal objections which can be urged against the scheme. It is believed that the whole of them are matters of detail which can be satisfactorily solved by the introduction of clauses into future railway Acts, without the opposition of the companies themselves, if (in order to disarm this opposition, and to prove to the companies that they would not be prejudiced, but, as before stated, benefited by it) private enterprise first showed the value of the proposed scheme.

It is, accordingly, in contemplation to try the experiment by a private association on (say) twenty arches. Such an experiment can in no way be a very bad, and it is possible that it may be a good, investment.

If the latter is found to be the result, it will then be possible, without the opposition of the railway interest, to introduce into future private Acts some such compulsion clauses as the following:

1. Compensation, pro rata, for outlay in building to be given to tenants of dwelling-houses under arches, in case of summary eviction.
2. Where a viaduct is required to be wider than 30 ft. (or two lines of railway), to build a second viaduct at a distance from the first.
3. 50 feet land to be bought to get access on one side (say 15 ft. in width), and light on the other side (say 6 ft. in width).
4. Standing orders to be altered to a compulsory minimum height of 20 ft. to crown of arch.
5. Fireplaces and flues to be constructed in piers and parapets.

These clauses, though entailing an extra cost upon the railway companies, would repay them in the rent obtainable from the dwellings.

In all future railway schemes which come before Parliament for sanction, the policy also should be in favour of constructing overground railway rather than underground railways. In all of the latter class, with the exception of those under carriage-roads, property is destroyed without an opportunity for provision being made for those dispossessed. In those of the former class, it may be possible to provide dwellings for nearly the whole number of passengers.

The author has now indicated what he believes to be the best means to adopt to give good house accommodation to large numbers of the labouring classes at the present time, and to provide for future wants as they are created by the chief cause of the wants. It remains now only to prove that the commercial value of the scheme claims for it that support which its higher results demand.

The following figures are taken from a tenement of this nature on one of the existing lines of railway, and which is within the author’s knowledge.

The tenant, who is also lessee, a working builder, took the arch for 4 years, and built his house within it, consisting of two sitting-rooms, three bed-rooms, kitchen and wash-house combined, and offices, and states the cost at £100.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which at 5 per cent., gives</td>
<td>£5</td>
</tr>
<tr>
<td>Rates and taxes</td>
<td>£2</td>
</tr>
<tr>
<td>Insurance</td>
<td>£0 13</td>
</tr>
<tr>
<td>Add cost of collection (say)</td>
<td>£1 07</td>
</tr>
<tr>
<td>And repairs per annum (say)</td>
<td>£0 20</td>
</tr>
</tbody>
</table>

Total outgoings per annum (exclusive of rent of arch) ... £10 13 0

Now, at an estimate of 8s. per week for rent of the dwelling, the income from each arch, per annum, would be ... 20 16 0

Leaving a net income to the railway company on each arch, per annum, of (say) ... £10 0 0

On the thousands of arches in existence and in contemplation in and about London, the increase of revenue to the railway companies may at once be seen.

But taking the arches as worked by private enterprise, and even therefore as subject to an additional charge to the company of ground-rent, and taking this ground-rent at an average of £4 (an ample charge to cover the ground-rents of five-roomed dwellings in the district where these are contemplated), a further deduction of £4 would be made upon the above net income. This would leave an interest of £11 per cent. on their outlay to any company. And it is a simultaneous profit, free from risk, of £2 per arch per annum to the companies themselves on the thousands of arches which they will be in a position to lease.

In many districts in London large blocks of buildings have been erected with new materials, and on a scale which should not be attempted in the country, and a simultaneous profit, free from risk, of £2 per arch per annum to the companies themselves on the thousands of arches which they will be in a position to lease.


This is not a country nor an age prone to the publication of handsome architectural books. From time to time elaborate volumes leave the press, but their frequency has not kept pace with the rate of general advance of architecture. The work before us is, however, one of the most important and most novel which it has fallen to our lot to notice for a long time past, and forms some exception to this rule, for it introduces the architectural student to a series of fine examples, the merits of which are in England but little understood, may it be not too much to say, the very existence of which has been but barely known to the majority of Europeans; and it makes use of photography as a means of illustrating architecture in a more systematic and complete way than almost any previous publication. Many series of photographs illustrative of buildings have been published, and some books partially illustrated by photography have also appeared, but this volume appears to us more completely to develop the capability of this new art to lend itself to the highest class of book illustration, in the same way as the art of engraving has hitherto been used, than any previous attempt in the same direction.

To understand how it comes to pass that in Ahmedabad there should be found a series of buildings uniting the patient industry and endless elaboration in decoration of the Hindoo, with the purer architectural forms and uncloining skill in ornament of the Mahommcdan, we must go back some little way into the history of that northerly province of Western India known as Goorserat, of which Ahmedabad is the capital. Goorserat is a province marked out by well-defined natural boundaries, and having an extended sea-board. It is described in this volume as possessing great and varied natural beauty, and containing many cities and places of note, and as having from very early times maintained a strongly marked independence.

The population consists of several distinct elements, each holding its separate position in the whole, and resembling each other in little more than that they are bold and warlike. The aboriginal Bhels and Xhoolies, swarthy children of the bow, still lord it in the forest and on the mountain; but elsewhere they have either blended with, or been displaced by successive waves of immigration, among whom the fair-haired Kothi still proclaims his Skythin origin, and the chivalrous Rajpoot maintains his political supremacy.

Possessing as we have seen a central and naturally defended position, an extensive sea-board, a fertile soil, and a high-spirited people, Goorserat has from the earliest times had a distinct and self-sustaining nationality, a position in history disproportionate to its area, and a vitality which has over surmounted foreign conquest and internal strife."
The inhabitants of Goornerat appear to have held from early days the Jain religion, which is a form of Buddhism, and connected with which flourished a very distinct and remarkable architectural style, already well illustrated by Mr. Ferguson in previous works. Politically, the history of Goornerat was eventful, and even romantic, and Mr. Hope's historical sketch, commercial, and topographical description of the Chanar or Doon, down to our own day, will be read with great interest. In the tenth century, the Mahommadian invasion broke upon India, and early in the eleventh the Mahommadians assailed Goornerat, and even possessed themselves of Somnath, but they were eventually driven out of India, and did not again attack it for a century and a half; nor does it appear to have been at all generally established there till the end of the fourteenth century, and then only by dint of continued effort could it be maintained.

In the year 1412, Ahmed Shah, Viceroy of Goornerat, determined on founding a new capital, to which he gave the name of Ahmedabad, and which embraced in its circuit the site of one, if not more, earlier cities; and here we have reproduced that blending of the arts of the conquering and the conquered nations which has so often been seen in various parts of Europe; the Jain architecture of the existing temples and palaces becoming blended with that of the Mohammedans. The architecture, in two or three centuries, the base at least of some of these domical structures is tolerably shown, as seen from the interior of the buildings they cover.

The series of buildings comprising the great glory of Ahmedabad were completed within the compass of a century (the fifteenth of our era), although examples are given of later date. In what measure the architectural features of which we have endeavoured to point out the characteristics, were combined into the structures here illustrated, we can hardly attempt to describe. Without numerous illustrations, the effort would be almost futile, but in the book itself are combined both the needful illustrations and a lucid explanation from the pens of two practised writers. One hundred and twenty photographs are here given, and at a price for the whole volume which reduces their cost to below one shilling for each. They form a volume equally valuable for the study or the studio as for the drawing-room, and one which can be recommended with more than ordinary confidence to all who desire to form an acquaintance with this very distinct and singularly excellent school of art, hitherto all but unknown in Europe.

**NITRO-GLYCERINE IN THE SANDSTONE QUARRIES OF THE VOSGES, NEAR SAVERNÉ.**

The explosive properties of nitro-glycerine \([\text{C}_3\text{H}_5\text{(NO)}_3\text{O}_6]\), and the results of experiments made with it in various parts of Sweden, Norway, Switzerland, have induced Messrs. Schmidt and Dietrich, proprietors of extensive sandstone quarries in the valley of the Loire (Haut Rhin), to try it in their workings.

These experiments have been successful both as regards economy and efficiency, and the use of nitro-glycerine has been temporarily abandoned, and for the last six weeks only nitro-glycerine has been used for blasting purposes in these quarries.

1. The preparation of nitro-glycerine is commenced by mixing in a vessel, placed in cold water, fuming nitric acid, at 49° or 50° C. (118° to 122° F.) with 1.456 or 1.468 eutactic alcohol, until its weight is equal to the weight of the strongest sulphuric acid. (These acids are both expressly manufactured at Diest and sent to Saverné.)

The gloceric acid of commerce, which should be free from lime and lead, is evaporated in a vessel until it indicates 30° to 31° Baumé (1.245 and 1.250 sp. g. English). This concentrated form should be kept in a cool, never completely cold. A workman then pours 3,300 grammes (about 7½ lbs.) of the mixture of sulphuric and nitric acids, well cooled, into a glass vessel (a stone pot or porcelain vessel will equally answer the purpose), placed in a trough of cold water, and then pours slowly, while gently stirring it, 600 grammes (1lb. 10oz.) of gloceric acid. The most important point is to prevent any sensible heating of the mixture, which would cause a rapid oxidation of the gloceric acid with the production of oxalic acid. It is for this reason that the vessel in which the transformation of gloceric into nitro-glycerine takes place, should be constantly kept cool externally with cold water.

The mixture being stirred well, it is left for five to ten minutes,
and then it is poured into five to six times its volume of cold water, to which a rotating motion has been previously given. The nitro-glycerine is rapidly precipitated in the form of a heavy mass, which is collected by decantation in a deep vessel; it is then once washed with a little water, which is also decanted, and then the nitro-glycerine is poured into bottles ready for use.

In this state the nitro-glycerine is still a little acid and watery; but this is no drawback, as it is used shortly after its preparation, and these impurities in no wise impede its explosion.

The Properties of Nitro-glycerine.—Nitro-glycerine is a yellow or brownish oil, heavier than water, in which it is insoluble, but it dissolves in alcohol and ether. Exposed to a cold, even slight, but prolonged, it crystallises in long needles. A very violent shock is the best mode of making it explode. Its management is otherwise very easy, and not dangerous. Spread on the ground, it is difficult to make it take fire with a light match, and even then it burns but partially. A flask containing nitro-glycerine may be broken on stones without exploding it; it may be volatised without decomposition if carefully heated; but if the ebullition becomes brisk explosion is imminent.

A drop of nitro-glycerine falling on a cast iron plate moderately hot, volatilizes quietly; if the plate is red-hot, the drop inflames immediately, and burns like a grain of powder, without noise; but if the plate is hot enough, without being red-hot, for the nitro-glycerine to boil immediately, the drop is briskly decomposed, with a violent detonation.

Nitro-glycerine, especially when impure and acid, may decompose slowly after a certain time, with release of gas, and production of oxalic and glycolic acids. It is probable that spontaneous explosions of nitro-glycerine, the disastrous effects of which the newspapers have made known, are occasioned by a similar cause. Nitro-glycerine being enclosed in well-cooked bottles, the gas produced by its spontaneous decomposition cannot escape through the bottles, and thereby exercises a very great pressure on the nitro-glycerine, and under these circumstances the least shock and the slightest shaking may occasion an explosion. Nitro-glycerine is of a sugary, sharp, and aromatic flavour; it is also a poisonous substance. In very small doses it is said to be a harmless; its violent power as a reducing body, and the circumstances under which it is used as a frightening body, such as hydrogen, glycerine is set at liberty, and caustic alkalis decompose nitro-glycerine into nitrates and glycerine.

3. Methods of using Nitro-glycerine.—Supposing that it was required to detach a mass of rock at 2.50 metres or three metres (8 or 10 feet) from a horizontal edge; a handsome gun shot, about two to three metres (from 6ft. 6in. to 10ft.) in depth, five to six centimetres (2 to 2½ inches) in diameter; after having cleared this hole of mud, water, and sand, 1,500 to 2,000 grammes (5lbs. to 7lbs.) of nitro-glycerine are poured into it by means of a funnel. A small cylinder, in wood, card, or tin, of about four centimetres in diameter and five to six centimetres (1 inch, 2 to 2½ inches) in height, filled with powder, is then put in. This cylinder is attached to a fuse, that penetrates it a short distance, to ensure the explosion of the powder. By means of this the fuse is lowered to the surface of the glycerine, which is known by practice.

The fuse is then held steady, and fine sand is run in until the hole is entirely filled. It is unnecessary to compress or plug up the sand. The fuse is then cut off a few inches above the hole and lighted. At the end of a few minutes the fuse burns down to the cylinder and ignites the powder, which occasions a violent shock, and causes the nitro-glycerine instantly to explode. The explosion is so violent that the sand over the water has time to shoot out. The whole mass of rock is raised up, displaced, settles quietly down without any being projected, and a dull report is heard. It is only on the spot that any idea can be formed of the immense force developed by the explosion. Formidable masses of rock are easily displaced, and cracked every way, and results more by mechanical means. The principal advantage is that the stone is but little crushed, and there is but little waste. With charges of this nitro-glycerine, 40 to 80 cubic metres (1,400 to 2,800 cubic feet) of pretty hard rock may be detached.

Bell Founding.

Mr. H. M. Braws, in his contribution to the recently published work, entitled "Birmingham and the Midland Hardware District," writes:—This trade seems to have been unknown in Birmingham till the middle of the last century, when a foundry was in existence opposite the Swan at Good Knave's End, on the road to Harborne. This country supplied peals of bells to three adjoining parish churches in 1760. Twenty years later, one Ducker had a foundry at Holloway Head, and cast chimes, since which time there is no record of large church bells in peals having been cast in the town, although an extensive trade in other descriptions has continued to flourish and extend. Church, school, plantation, factory, and ship bells still closely adhere to the medieval type. They vary in size from half a hundred-weight to half a ton, the largest size now cast at Birmingham. There is a great demand for them in the home and nearly every foreign market, including South America, and the Colonies, Railway and dinner bells, from four to seven inches wide at the mouth, with a wooden handle attached, are largely used for domestic purposes; and the majority of railways in England, India, Russia, Brazil, &c., have been supplied from Birmingham. Musical hand-bells are still made, but the demand is very limited, as they are seldom required by any but village ringing clubs. Cattle and bellows are obtained from two and a half inches to seven inches by two-and-a-half inches to seven inches by three-and-a-half inches by two-and-a-half inches to seven inches by three-and-a-half inches. They have conical sides, and a square iron loop at the top. They are in great demand for Australia and New Zealand, the smaller sizes being suited to the Brazilian and South American markets. Sheep bells are made in the mouth in various shapes, with a loop at the crown. They are used in England, and exported to the Cape, Australia, New Zealand, &c. Horse bells are so familiar, as to need no description. Some exceedingly small bells, from 1 to 1½ inch, are used as an article of barter in the African trade. Sleigh, dray, and carpenter bells, small circular bells with an iron ball cast inside, are largely used in Canada and India, and command a limited sale at home. During the last ten years an increasing demand has arisen for fancy, table, office, and call bells, constructed of the ordinary clockwork, mounted on a stand, and struck by the pressure of a spring. Not very long since, Messrs. Schofield, Sons, and Goodman executed an order for 10,000 green bronze and lacquered house bells, 12oz. in weight, for a West African Prince, to adorn his new iron palace. Messrs. J. Wilson Browne and Co. recently also received an order from another African prince, for a number of polished ship bells, in elegant brass frames, and mounted on mahogany stands, some of which were engraved with the name assumed by the distinguishing potentates, "Yellow Duke, B.B."
THE ARCHITECTURAL ASSOCIATION.

The regular fortnightly meeting of this Association was held on the 9th November, Mr. R. W. Edin, President, in the chair. Mr. S. Lane, Mr. M. Ferguson, Mr. William Davis, Mr. Frederick H. Reed, T. H. Watson, Mr. Arthur Briggs, Mr. Thomas Kedge, Mr. Reginald Worsley, Mr. C. W. Phillips, Mr. R. T. B. Price, Mr. R. S. J. Walker, Mr. W. H. Arber, Mr. R. W. Woodcock, Mr. Edward Newson, Mr. George Allin, Mr. F. M. Harvey, Mr. Charles Bell, Mr. D. J. Rose, Mr. Talbert, Mr. Arthur Vernon, Mr. A. S. Allsop, and Mr. W. G. Davies, were elected members of the Association.

An address was then delivered upon

THE RELATIONS WHICH SHOULD EXIST BETWEEN ARCHITECTURE AND THE INDUSTRIAL ARTS.

By M. Dibbey Wyatt, F.R.I.B.A., F.S.A.

Mr. Lecturer commenced his address by stating that, one primary object which he had in addressing the Association was, to call the attention of young architects to the importance of being ready to seize upon any new invention or discovery, any new materials, or processes, or revivals of ancient processes, or desired materials, and to fit themselves for introducing them with judgment, to success in their building. His purpose was not then to compare the relative merits of one style of architecture with another, but rather to show the means by which all styles might most safely and surely advance and keep pace with the requirements of the age. There was a continual debate about new styles of architecture,—a cry for something different from the old,—in the standardised structure; but it was not by inventing new styles, but by improving and advancing the styles which we possessed, and by the introduction of new materials, that architects would be enabled to obtain novelty and freshness in their work. Progress in the industrial arts was steady and constant, owing to their dependence upon the incessant wants of humanity, and there was a natural connexion between those arts and the architect, as between master and servant. New inventions were being continually introduced to the architect, to be made use of in his work; and it was by availing himself of this natural connection that the architect would advance in a right and safe path. Knowing this, architects should take great interest in manufactures, in the introduction of new technical elements, and in the formation of new materials and processes. "More novelty" was to be got by altering and bringing in adjuncts from industrial arts which had not been herefore habitually applied to architecture, than by attempting to assimilate the old with the new. The potter had been constantly used by our forefathers, and twisting them into forms different from those hitherto seen. Mr. Wyatt said, that if the members would carry their mind's eye back for twenty-five years they would at once recognise the great advances which had been made. He instancest first mosaic work. Twenty-five years ago there was archery association in this country. Now, one could scarcely pass along the street without seeing large pieces of pavement covered with it, so universally had it come into use. It was also rapidly spreading over wall surfaces, and he believed it would ultimately change the whole style of the interior architecture of the finest ecclesiastical structures of the land. Again, in the article of stained glass. Twenty-five years ago it was quite rare. Now, it is quite common, and its introduction or non-introduction altered the effect of the entire building. He thought they could scarcely have the brilliant colours in the windows without wishing to have colours also on the solid surfaces which surrounded them. So the architect was led on to make his design richer and richer by the introduction of new materials. Thus he might restore to the skeleton of the grandest monument time had alone bestowed, to him from past ages, those elements which once made it a living form. The architect must engraft on the works of the past, and he could only do that by making his work harmonise with his. All the various modes of mural decoration; if he could design paper-hangings well, he could also, by a little special study, learn to design carpets, curtains, etc. Generally, and he would be in a position to exercise a trained taste and judgment in any department of industry, even to selecting or composing that most difficult problem a lady's dress. The same process of study carried on by the natural principle of dependence which led from one art to another, enabled him to follow out every branch of design. Having once acquired a knowledge of paper hangings, he could, without difficulty, master the separate details of each special branch, so if a student made himself acquainted with the laws of sculpture in its various plastic forms, not only in the round, but upon flat plain surfaces, and also upon curved surfaces, he would have the knowledge to design on a smaller scale in relation to works of industry. By the correct sequence of things, everything in the way of designing gravitates naturally towards the architect. His mind should be trained to appreciate whatever was artistic with special relation to the
material employed. If an article were designed with beauty and
taste, the architect would see it and feel it the moment he looked
on it; in fact, having had the mental training, he could scarcely
keep himself from the practice of industrial design. Looking to
metal work as an illustration, it would be found that architects
had almost involuntarily of late years changed its character alto-
gether. The various books written by archaeologists had called
attention to this branch of industrial art, but the architects for
the most part had given the revived and beautiful forms it was
now frequently seen to assume. Till lately it had been very
much lost sight of, but when men began to think about it, and to
insist upon taste in ironwork, improvement commenced, and
people would not now tolerate bad designs. In this manner not
only artists, but the public and the trades were benefited. The
new plays that people had seen in Paris and London, and as box
tickets were cheaper, the public could buy them; and this
had been done twenty or thirty years ago; and this improvement in
the industrial arts had been effected mainly through the influence
of the architects. Artists and architects had not sought
sufficiently industry, but industry had sought the artists. He
(Mr. Wyatt) strongly recommended students to exercise them-
selves in designing for the industrial arts to which he had been
referring. To design for those arts required the same general
power of combining which was necessary in an architectural
edifice. Thus whatever an artist designed, he should make
specific in its function; if it were a box which he designed, its
purpose should be borne in mind, and it should be a box, and
not a box designed as an altar, as boxes are designed externally.
The purpose of an article, as of a building, should always be expressed by its external configuration.

The same quality in an architect’s mind which made him
design a church like a church, or a warehouse like a warehouse,
should enable him to make a box like a box, or a chair like a
chair. In the same way that the architect designs a building,
be it a temple, or a palace, or a house, or a box, so he designs
an altar of the golden altar at Milan, the Pala d’Oro at Venice, or the
carvings on the screens of some of the Parisian churches,
were studied, it would be found that all of them had been
designed by men who had made metal work and wood carving
belong to architecture. An architect’s duty was to create
beautiful things, big or little, cheap for the million, sumptuous
for the millionaire, and he ought not to turn away from the
manufacture of any ordinary objects upon which the stamp of
beauty might be impressed. Mr. Wyatt said he did not need to
remind them of the number of architects who had been not only
active in the new artistic branches of art, but in the old
industries. Artists and architects of the industrial branch.
Old masters were fruitful of men who were not only architects, but goldsmiths and metal
workers, and who took as much interest in wood and ivory
carving as in the design of a large building. He (Mr. Wyatt)
had with him a number of original designs by old masters,
which he had lately had an opportunity of purchasing in Italy,
showing that it was in the power of an architect to make him-
self master of the details, both of his own profession and of
the industrial arts. (The sketches were mostly details of wood
and metal work, majolica, wall painting, and stucco and graffito
work.) Mr. Wyatt continued his remarks by observing that these
sketches were of the works of the great masters of the art,
and the finest artists, who would best enter
into the special technical requirements of industrial art. He
believed that wherever society had been highly cultivated,
the highest artist had been employed to make industrial objects
beautiful. Many of the ancient architects were universal in their powers of design, and
their work was beautiful. Not only the artists
with Raphael were special instances during the period of the
reinassiance in Italy, and during the best times of Greece and
Romel the same universality of power was noticeable.
The same intellects which constructed the great buildings of the
country, were also able to descend to little industrial details;
and the same unification of the thought, the vitality,
could not exist without the other. For the opportunity of
noticing and generalizing such facts regarding ancient work,
artists were much indebted to the Manchester Exhibition of
1857. He had specially noticed at that exhibition the vitality
which was shown in every branch of artistic production at the
great culminating periods in the history of monumental art.
There was a general harmony among the objects exhibited,
and the beauty of taste and finish. If production might have been,
yet as the highest point of artistic power was
reached, there was found to be a common feeling pervading
them all. It was the same colour lighting up the highest peaks, and
the beholder could see that there was the same art, the same
nature, and the same God ruling above all. To the Crystal
Palace, the Hotel Cluny, and the Kensington Museum also the
artistic world were under great obligations, as in those
interesting collections the same general principles to which he (Mr. Wyatt) had adverted, were noticeable. No country in the
world, not even France, had such a collection in which the
student could so readily observe the connection between the industrial arts and the architects, as we possessed, thanks to
Mr. Cole’s energy and Mr. Robinson’s fine taste. South
Kensington. In the museums in Paris, it was true there
were many beautiful objects, mostly of the renaissance period, and their “loan collection” of the year before last had been most
instructive. There might have been seen multitudes of old
architects worthy of active revival by modern architects, such as
inlays, veneers, and new modes of designing joiners’ and cabinet
makers’ work, in the study of which latter the observer was
made to take a delight in the ingenious complication of the true
art workman revelling in his craft, and had his perceptions of
beauty in that field of design altogether quickened. There were
also in the Paris Exhibition some of the finest specimens of
Henri II. ware, especially suggestive for ceramic revivalists, as
well as some beautiful specimens shewing the art of applying
ceramic. There had been another continental exhibition, especially
interesting from an ecclesiastical point of view, at Mayence.
Mr. Wyatt produced a fine series of photographs of articles in
that city, shewing the very great artistry which
was exhibited, especially those showing the metal work of Namur, wrought by
that magnificent art workman of the thirteenth century, “Hugo
des Oignies,” and the “dinandierie,” or old ecclesiastical “latten
work” of Dinant.

In speaking of the relations between the industrial arts and the
architect Mr. Wyatt begged his hearers to bear in mind
that it was not only the industrial arts which might be benefited
by drawing closer the bonds of intimacy, but that the architect
also would be correspondingly and reciprocally benefited.
There was no class of practice which was more improving to the young
architect than one in which he could not only design, but could
have his design executed. There was a great difference between
making such a design and one which passed only to the student’s
portfolio, without being really put into execution. The latter
had not half the instruction which it would have were it to be
executed. Only then could the designer discover his faults,
and correct them, and by this means become a designer. Now, a student or young architect could rarely get this in the form of a
large building, but he could readily find in some small industrial object,
which might only cost a few shillings; and thus his taste and
judgment were exercised, and he was trained for larger works
when called on to design upon a larger scale. With such
practice and experience, he would not be nervous about how his
building was going to look. Let him but give himself training
in designing industrial objects, and he would find that he would
easily anticipate what his drawing was going to look like, and
this knowledge would give him strength to advance when called
to deal with responsible problems. A somewhat baser con
consideration might be the desire to get and hold a situation,
the money paid him for the production of designs. The manufacturers
of the country were earnestly looking out for intelligence. Manufactu-

ers did not want draughtsmen and modellers only, but artists
with knowledge, taste, and talent. Many of the industrial arts
had improved, but there was still much room for advance-
ment. He held it to be important that the architect should design
his own objects which were to be made by others, rather than
commission them. The Architects’ Association was the instrument
from the philosophy of Plato to the gem he might have worn
upon his finger.

Mr. Stras said the subject which had been brought before the
Association by Mr. Wyatt was most important, and deserved the earnest
attention of young architects. The enormous extent of the publication
of drawings and photographs of every known style had since the sixteenth century procured in the line of the works, in which it was difficult to know that in an ordinary domestic dwelling, as many distinct styles might be formed in the furniture, carpet, &c., as there were rooms in the house, or even articles of furniture. In France, however, a certain consistency has always existed in the interior decorations of the rooms, furniture, &c., and the exterior arches of the churches, and the whole of each of the - the works of Louis XIII, Louis XIV, and Louis XV, may be said to have possessed a distinct style. The architect's attention, therefore, should be drawn to the furniture of a house, as well as to the exterior design. He (Mr. Spier) had noticed a growing interest in industrial subjects in the classification of design in connection with the Association. Sideboards, chimney-pieces, church plate, &c., had been treated at various times, and last year the decoration of a chapel at St. Anselm, an extremely difficult subject, had been well worked out. It was probable that an architect interested in this subject would copy upon design fresco paintings on church walls, but it was as well he should have ideas and judgment in the matter. Next year, when the Paris Exhibition is opened, we shall have an opportunity of judging of the progress made in this line. Of course Mr. Spier would remember the Exhibition of 1851, and was able to note in 1862 the progress which had been made in the interim. Whilst we had learnt much from our French neighbours before, now perhaps something might be learnt from English work. He (Mr. Spier) had noticed a growing interest in studies of glass and iron; whilst in architecture proper, the employment of coloured materials, of bricks, tiles, marble, &c., in our exteriors, might offer many suggestions to French architects, who hitherto had designed in plain stone. The latter concluded by moving a vote of thanks to Mr. Wyatt for his excellent lecture.

Mr. Matthews seconded the vote of thanks. The Association was greatly indebted to Mr. Wyatt for his valuable lecture. It was one that members would not soon forget, and it is hoped it would stir them all up to attention to the minor details of their art.

The President, in putting the vote of thanks, observed that it was very disagreeable for a young architect to find after he had designed his house with all careful thought and labour, fancy, and judgment, wretched design of the chairs and other furniture in the internal embellishments of the dwelling. Architecture was not only an art but a science, and the student must bear in mind that if he studied it only as an art, and not as a science, he was in danger of becoming a mere theorist. He quite agreed, however, with all that Mr. Wyatt had said, but considered that the one difficulty was the greater expense of furniture specially designed; he believed that architects were sufficiently competent to design artistic furniture, but it was somewhat difficult to design it sufficiently to cost less than cheap articles, and they would rather endure the ugly designs than pay more for really artistic work. He (the President) had often tried to get clients to have furniture designed, and they had always said, "what will it cost?" The answer of Mr. Spier was that it would cost a little more in that it had been made by great artists with great care, and the people had always declined to get it done. It was only when manufacturers could be got to do things cheaply from architects' designs that art furniture could be obtained. So long as they threw obstacles in the way of the architect, he could not present his ideas in a form that was beautiful and artistic. He could not comprehend why cheap things should necessarily be ugly things. The common articles of the ancientians were always beautiful and artistic, and people now paid high prices for antique vessels, which were not only beautiful, but valuable. For five or six hundred years hence, give guineas for a ginger beer bottle of the nineteenth century! It was quite clear that the relics of ancient times which were stored in museums were valued because they were objects of beauty. In those days man had a respect for the past, and was not as careless in the treatment of the articles they put in their windows. The President concluded by thanking Mr. Wyatt for his valuable address, and putting the vote of thanks, which was carried unanimously.

Mr. Whitehead, in moving for the vote of thanks, observed that the difficulties which had been referred to were but additional reasons why architects should give greater attention to the subject he had had the honour of bringing before them. Manufacturers might be still conservative in their trade principles, but they had been well stirred up, and ought to be so still more, and made to move on in the current of improvement. Pugin did much to urge them forward in the path of progress, and it was by other architects continuing what he had so well commenced that they would become interested in objects of industrial art in good taste, and at such moderate prices as should render them rather the rule than the exception throughout the country.

Spanish Railways.—The line of railway crossing the passes of Sierra Morena is now open for traffic; thus the journey may be made without interruption between Paris, Madrid, Cordova, Seville, and Cadiz. Within a few months, Madrid will be united with Lisbon by the Badajos Railway.
usually built of masonry or brickwork. Latterly, however, this restriction has been removed; and considering the success that has, in every point of view, attended the erection of Westminster Bridge, and the probable success that will also accompany the construction of new Blackfriars Bridge, it is almost certain that our bridge builders will not be backward in attempting similar materials. An example of the erection of a wrought-iron bridge for the purpose of carrying street traffic, has very recently been afforded in Paris. It is the object of the present paper to give a general and detailed account of this recent construction, which possesses some features of peculiar interest to the engineer who lives in the metropolis where the ancient city of London is known by the name of "La Place de l’Europe," and is appropriately so termed, since it is the common focus to which converge six of the principal streets of Paris, named respectively "London-street," "Berlin-street," "St. Petersburg-street," "Constantinople-street," "Vienna-street," and "Madrid-street." Without reflection, it might be supposed, granting that there was a choice in the matter, that it is bad engineering to run a line across the junction of roads and streets, whereas it is in reality a point to be aimed at in laying out a line of railway, as one bridge thereby answer the purpose of several. It is true that it will probably be larger than any one of the others considered separately, but it is cheaper to have one large one than three or four small ones. The late extensions of our metropolitan lines in and about London will furnish numerous examples of the junction of several roads and streets being crossed by railway bridges both under and over. The plan of the bridge every part of the plan, and in particular the method of abutment and the necessity for preserving the directions of the converging streets unaltered. In London, where a glance at the railway is sufficient to convince the observer that the question of utility is paramount to every other consideration, we should unhesitatingly have sacrificed the gardens in the angular portions of the ground, divided each pair of side streets into the main channels, Berlin and Madrid streets, and by so doing reduced the size and cost of the bridge to about a third of its present dimensions and value. There is very little doubt, however, that the engineer had no choice in the matter; a paternal government marked out his ground-plan for him, and all that he had to do was to employ the most economical means of carrying the traffic clear of the street, and by the most convenient abutment and at the other on the skew, and are not continuous over it. They have, therefore, a constant span of 101′90″. The distance from centre to centre of the nine intermediate girders is 18′45″, being about 18″ more than that of the intermediate girders. The girders supporting Vienna-street are in number and supported partly by the square abutment and partly by the face girder. The span of the shortest is 21′95″, and that of the longest 97′9″. Of those under Constantinople-street the shortest has a span of 23′4″, and the longest of 93′6″. Those under St. Petersburg-street are also five in number, the first having a span of 7′20″, and the last of 18′20″. The girders under Vienna and Constantinople streets are 18′29″ apart from centre to centre, and those under St. Petersburg-street are placed the same distance apart as the intermediate girders. The reason for these varying distances is probably the desire to divide the spans of the face girders into a number of bearing joints equally distant from one another. The girders resting under the main girders, of which the distances between their respective spans are not constant. Those in the central part of the bridge placed between the intermediate girders have a span of 16′21″, and those between the girders in the angles of 18′22″. All the face girders are what are known as double lattice girders, and, in order to preserve an uniformity of appearance, the dimensions of the lattice girders although their spans vary considerably. The intermediate and the girders under the side streets, with the exception of those under Vienna-street, are also of the double lattice form, but of a simpler description. The girders in the corners, in consequence of the limited dimensions of their spans, are single lattice girders. The girders resting upon the fixed girder supporting Vienna-street are of the plate form, two of them being single or plate girders proper, and three of them being double, or what are known as box girders. The whole of the cross girders are plate girders.

One of the principal difficulties to be overcome in the construction of the present bridge arose from the streets being on different levels. It is a common enough observation that "facts are stubborn things." Well, levels are engineers’ facts. They cannot be disregarded or got rid of. A diversion of a road or stream may frequently be accomplished in half a dozen different ways. The engineer has to consider first the level of each section, and there no choice but to adopt the only gradient that can be got. The rise in Vienna-street is 1 in 28, the whole rise of the street being obtained in the span of the face girder V, the roadway continuing horizontal over the central part of the bridge. This difference of level is provided for by constructing the roadbed in the eleven face girders from one end to the other and unequal depth. The consequence of this difference of level in the streets is to cause the roadway to be suspended at about the centre, vertically, of the face girders, and to produce both an unequal
and unscientific appearance. The distribution of a load either over the top or bottom of a girder appears, so to speak, natural; but the proportion given to it in the elevation has not only rationally an unsightly aspect, but the position that the load can occupy, since it is in close proximity to the neutral axis of the girder. The actual disadvantage resulting from so placing the load depends, in a great measure, upon the amount of vibration exercised by the movable portion of it. In a bridge similar to that at the Place de l’Europe, where ordinary street traffic has only to be provided for, the concussion of a moving load may be neglected, as it will be absorbed in the mass of the bridge, whose vis inertia would more than compensate for any slight shock occasioned by the passage of a very heavy weight. In railway bridges, unless of very large spans, these conditions do not apply, and the moving load produces a greater effect on the fixed or static load. The author considers that the face girders supporting Vienna-street might have been placed on the incline of 1 in 28, and the central girders raised to the level of the present streets with considerable improvement in point of appearance. The roadway and its support would then appear in their proper relative positions, the centre of gravity of the whole structure, together with its load, would be lowered, and the rigidity of the bridge increased. The cost of raising some of the piers would be counterbalanced by the reduced height in the abutment, and, if otherwise, the additional expense would be very trifling. The end spans of Lambeth Bridge are upon an incline of 1 in 22; the same is true of the bascule and cantilever of the structure, yet it is doubtful whether the inclination of the shore ends has anything to do with its want of beauty. The masonry of the Paris bridge presents no features worthy of particular notice. The piers and abutments are faced with coursed ashlar, dressed and chamfered, and relieving arches are built in them between the solid plasters, supporting the ends of the girders. The greatest pressure upon the square abutment is 1.96 tons per square foot upon one of the square piers, and upon the skew abutments 2 tons, and upon the other square pier and upon the skew pier 3.22 tons per square foot. The greatest pressure per square foot immediately under the bearing of any of the large face girders does not exceed 3 tons.

In a longitudinal section of a portion of the roadway, see Fig. 2, the cross girders are shown 6 5/6 ft. apart from centre to centre, and between them are turned arches of hollow bricks, 9 in. deep, and weighing 0.146 ton per foot run. The haunches of the arches are filled in with thin concrete, weighing 0.108 ton per foot run. Over the arches is spread a layer of asphaltum, rather more than 1 in. in thickness, and weighing per same unit of length 0.018 ton. On the top of the asphaltum the metallising is laid; it is 1 ft. in depth, and weighs 0.356 ton. Adding the weight of the cross girder itself, equal to 0.032 ton per foot run, we obtain for the total weight, supported by the cross girders per run, as shown in Fig. 2, or 1.15 tons. This, however, is only constant for the cross girders situated in the angles of the streets, and in the end spans of the intermediate girders. Those in the centre of the bridge, owing to the greater depth of metallising, carry half as much again, and may therefore be said to have a load per running foot of exactly 1 ton. Making W equal to the total weight per running foot, and putting d for the distance of the cross girders apart, we find

\[ W = 0.1008 \text{ ton} \times d, \]

the weight per square foot of the cross girders and roadway. Adding a proof load of 0.0366 ton, we obtain 0.1372 ton as the total load per square foot. The weight of the main girder is, of course, not included in the above calculations. In a similar manner, the maximum weight per square foot, occurring in the central part of the girder, will be found to be 0.1828 ton. The minimum load per superficial foot is therefore 22.5 lb., and the maximum a little under 36.6 lb. Of this total load, the portion 0.0386 ton represents the maximum live weight per square foot supposed to be brought upon the bridge, and is equal to 0.0386. This is nearly the proportion adhered to in main

of our own bridges. In apportioning the live load upon a bridge, the chief points to be regarded are its size and character. A smaller load per square foot may be assumed as the maximum for a large bridge than for a small one, as the effect of any violent and sudden shock will be more severely felt in the latter instance than in the former. Again, the situation and character of the bridge determine whether the ordinary assumption of the weight of a dense crowd as a maximum load is tenable or not. An iron bridge, especially a lattice girder, peculiar in the way in which it would be loaded to an amount considerably above what could possibly come upon a single bridge having the same area. Imagine the bridge at La Place de l’Europe under the circumstances attending a public royal departure from the terminus of St. Lazare. It is not too much to assert that not only every inch of space available upon the roadway and footpaths would be occupied, but every part of the sides and top; every nook and corner used. If the loading could be inserted, would be taken advantage of for the purpose of sight-seeing. Any bridge situated in a locality similar to the one in question, is liable to be thus overloaded. The author has seen the chains of Lambeth Bridge covered with a live load, in the course of the platform. The manner in which the final thrust of the hollow brick arches supporting the roadway is disposed of is very ingenious, see Fig. 3. It is manifest that although the arches rest upon the cross girders, yet the thrust of each half arch is resisted by that of its neighbour, acting in the opposite direction. This process of thrust and resistance is continued until we come to the last half arch, which has no fellow to take its thrust. This thrust is not taken by the abutment, as might be supposed, but the following method is employed. The last cross girder, upon which the arch rests, is tied by strong plate braces to the last cross girder but one, at the points of its bearing upon the main girders, thus transferring the thrust from the arch to the bridge. To further precaution, the last two arches are tied, the last by a diaphragm, and the last but one by a flat tie rod. This arrangement makes the iron and brickwork to form one complete frame, so that if we were to imagine the whole superstructure lifted bodily off its supports, it would still be self-containing. If the thrust of the last half arch were taken by the abutments, the effects of the expansion, by alteration of the temperature of the main girders, would be accumulated upon them, and the consequences might be serious. By the method adopted, the total expansion is subdivided at every cross girder, and the effect upon each arch is inappreciable.

The limits of a paper of this nature will not permit of a detailed investigation into the proportions and dimensions of the various girders constituting the superstructure of the bridge, and, moreover, there would not be the slightest practical utility in attempting the task. A description of the details of the most prominent will amply suffice to give a clear idea of the manner in which the work is designed and executed, and on such examples on a smaller scale would be wasting both time and labour. It has been already mentioned that the girder V, under Vienna-street, has the same span as that under Constantino-pleeet, and since that under St. Petersburg-street has a smaller span than both, we shall select the first as a fair type of the three. It is shown in elevation in Fig. 3, and in section in Fig. 4. Its construction is peculiar, and consists of two single lattice girders, connected by a strong vertical diaphragm, but with a small space left between the respective flanges. The span being 137.26 ft., and the depth 18.40 ft., the proportion is very large, being 0.737. It is clear that the girders under Vienna-street transmit half of their load to the abutment, and half to the main girder V, and that in consequence of the inequality of these loads, the main girder is very unequally loaded; the greatest weight being brought upon it at one extremity, and the least at the other. The girders are placed 18.30 ft. apart, and in order to find the total amount of the load brought upon the main girder we must first ascertain these weights separately. Taking the weight per square foot of the cross girders and roadway 0.1372 ton, and multiplying it by the distance, 18.30 ft., we have 2.52 tons as the weight per foot run of the girder V to V, which is constant for all of them. To find the weight transmitted to the girder V by each of them, let P equal the constant weight of the foot run of the girder V, and the weight per foot run of each of the girders itself; making L to equal the span, and W the weight brought upon the face girder by any of those V to V, we have

\[ W = \frac{(P + \pi \times L)}{2} \times \frac{L}{4}. \]

In the annexed table the weights, calculated by this formula, are given with the respective values of the letters:—

<table>
<thead>
<tr>
<th>Value of the Letters</th>
<th>Corresponding Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1372.0</td>
</tr>
<tr>
<td>2</td>
<td>18.40</td>
</tr>
<tr>
<td>3</td>
<td>18.30</td>
</tr>
</tbody>
</table>

85
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL  

December 1, 1866.

\[
W = \frac{(P \times p) \times l}{2} \quad P = 251 \text{ tons.}
\]

<table>
<thead>
<tr>
<th>( p )</th>
<th>( l )</th>
<th>( W )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V^2 )</td>
<td>0.089</td>
<td>29.198</td>
</tr>
<tr>
<td>( V^3 )</td>
<td>0.119</td>
<td>55.295</td>
</tr>
<tr>
<td>( V^4 )</td>
<td>0.179</td>
<td>61.760</td>
</tr>
<tr>
<td>( V^5 )</td>
<td>0.270</td>
<td>111.885</td>
</tr>
<tr>
<td>( V^6 )</td>
<td>0.323</td>
<td>140.732</td>
</tr>
</tbody>
</table>

Adding together these separate weights, we find the total load transmitted to the main girder to be 419 tons. The girder itself weighs 83 tons, which will make the total weight it has to carry, in round numbers, 502 tons, which is equivalent to 3'55 tons per square foot. This load is so distributed upon the ends of the girder and the latticework that the point of maximum strain on the flanges will not correspond with the centre of the span. It should be remarked here that the French engineers in their calculations have taken the clear span between bearings, and not the distance between the centres of bearings as is sometimes done. The distances from the abutments can be easily found from the principle of the lever, upon which is based all the theory of horizontal girders. Let \( R \) and \( R' \) be the two reactions, taking \( R \) to represent the greater, or that upon the square pier, and \( R' \) the lesser, upon the abutment. If \( \sigma_1, \sigma_2, \sigma_3, \&c., \) be the stresses calculated for the girders, \( V^2, V^3, V^4, \&c., \) and \( d_1, d_2, d_3, \&c., \) their distances from the abutment, \( L \) the span of the girder, \( V \) and \( W \) its total weight, we have

\[
R = \left( \frac{\sigma_1 \times d_1 + \sigma_2 \times d_2 + \sigma_3 \times d_3 + \&c.}{L} \right) + \frac{W}{2}
\]

Similarly,

\[
R' = \left( \frac{\sigma_1 \cdot (L - d_1) + \sigma_2 \cdot (L - d_2) + \sigma_3 \cdot (L - d_3) + \&c.}{L} \right) + \frac{W}{2}
\]

The value of \( R \) is thus found to equal 350 tons, and \( R' = 150 \) tons. It is evident that since the total weight supported by the girder is equal to \((R + R')\), when one of the reactions is known, there is no necessity for working out the equation. The principle adopted by the French engineers in designing the girders is that of determining, firstly, a minimum section of flange which is constant throughout the whole span, and then of adding such additional plates at the centre and elsewhere as the amount of the struts may render necessary. The reverse is the usual method employed by us. We generally first ascertain the maximum sectional area required, and then drill the flange plates accordingly as the decrease in the strains towards the supports will allow. The former method is synthesis; the latter, analysis. The object to be gained in making each girder to consist of two separate girders is not by any means apparent, as all the diaphragms and stiffening in the world would never make the two act like one, and necessarily involves a much larger amount of bracing and extra material than what would be otherwise required. This will be evident on comparing the diaphragm in the sections with the light lattice bracing between the separate bars in the Charing Cross and Blackfriars bridges. The diaphragm is composed of a plate \( \frac{5}{8} \) in. in thickness and is riveted all round to angle-irons \( 4 \times \frac{1}{4} \) in. \( \times \frac{1}{8} \) in. There is an especially peculiar to be remarked in the manner in which the sections are built up. It is the introduction of the angle-irons at the outside edges of the flange plates, which almost seem as if they were placed there for the purpose of covering or protecting the edges. The compression bars are of channel iron, which is undoubtedly the best section that can be used when a large sectional area is required, but it is not so well adapted for bars of a small section. For these, and, in fact for all ordinary purposes, there is no section which, for cheapness and facility of procuring, can compare with angle-iron. T-iron is also an excellent form of section for large compression bars, but when used on a small scale there is a loss incurred, in consequence of the necessity of riveting it on both sides of its rib. All the ties are of flat bar iron, riveted at the crossings to the back of the channel iron. Except at the points of loading, which are diaphragms, which are not connected, there is no connection between the webs of each separate girder composing the section. The points of intersection of the struts and ties are 6ft. apart, and the greatest length of unbraced strut is a little over 7ft. The lightest section of channel iron used is \( 3 \times \frac{1}{4} \) in. \( \times \frac{1}{4} \) in. \( \times \frac{1}{8} \) in., and, as it might be expected, \( 1 \frac{1}{2} \) in. \( \times \frac{1}{4} \) in. having a weight of about 7 square inches. The section is therefore still enough to dispense with any intermediate bracing for the above length. The minimum section of this girder is built up of four angle-irons, two to each of the separate flanges, of \( 4 \times \frac{1}{2} \) in. \( \times \frac{1}{8} \) in., or \( 4 \times \frac{1}{4} \) in. \( \times \frac{1}{8} \) in. The author is of opinion that it would simplify the calculations to give all the French measures of angle-irons and plates in their usual corresponding English dimensions, but was compelled to renounce the attempt, as the sectional areas calculated thereby would not tally. It would also have increased the labour very considerably, and involves a double calculation. The few tables available for converting French weights to corresponding English weights are too little better than useless for scientific purposes. They serve in some instances as a check for one's calculations, but for nothing more. In addition to the four angle-irons there are two plates \( 17 \frac{1}{2} \) in. \( \times \frac{1}{4} \) in., and also the two angle-irons at the edges \( 3 \times \frac{1}{4} \) in. \( \times \frac{1}{8} \) in. of the plate at the ends of the girder, which are included in the calculation of the total area. The two side plates are each \( 17 \frac{1}{2} \) in. \( \times \frac{1}{8} \) in. The total gross area is 6'372 square inches. At the point of greatest strain this area is increased by the addition of extra plates, all \( 72 \) in. in thickness to \( 97 \frac{1}{8} \) square inches, the total thickness of flange being 3'4in. The strain per square inch of gross sectional area upon the flanges, exclusive of the strain per same unit of area in any part of the bridge, is not greater than 3'82 tons, and the metal has been apportioned upon this datum. This is rather a low factor of safety, and perhaps accounts for the fact that there is no difference made in the sectional areas of the top and bottom flanges.

The ends of the girders are secured by plates and angle-irons, and it will be sufficient to investigate the strain upon the heavier end, or that resting upon the square pier. The available material to resist the strain consists of one plate 11'21 ft. \( \times \frac{1}{8} \) in., giving a section of 79 square inches; of eight angle-irons \( 4 \times \frac{1}{2} \) in. \( \times \frac{1}{8} \) in. \( \times \frac{1}{8} \) in., having a total section of 2'8 square inches, and \( 0.45 \) in. \( \times \frac{1}{8} \) in. of the same material. The total end sectional area is therefore 147 square inches. The strain upon the heavy end of the girder has been already ascertained to be 350 tons, and we therefore find the metal to be strained to only the amount of 2'31 tons per unit of area. Although the strain is very small, yet it must not be supposed that there is a corresponding loss of material, for the ends of the girders, particularly of lattice girders, require to be made extra strong. The principal object to be kept in view in designing the end of a lattice girder is, that all the strains brought by the bars upon the end pillars should be conducted to a rigid bearing, and should not have to draw for support upon any of the neighbouring bars placed between them. The work to do, and should not be loaded in addition with strains belonging to another part of the structure. There is no doubt that solid end plates offer the easiest method of accomplishing this result, but at the same time it is the most uneconomical. There is no more necessity for a lattice girder to have solid ends than for a plate or box girder to have open ones. In consequence of the unequal distribution of the load, and the point of maximum strain not occurring at the centre of the span, but at the point \( Y \) (see Fig. 3) it is here that the load may be supposed to divide, and be ultimately transferred to the supports, in the proportions previously described. The angle of inclination of the lattice bars, in \( Z \times Z \) or \( H \) horizontal bars, is 1 to 1. The ratio of the strains upon the bars to the vertical strains is therefore as 1.44 to 1. The tie-bars, starting from the point of greatest strain, and proceeding towards the abutment from 1 to 7, are each 9'84 in. \( \times \frac{1}{8} \) in., and since the girder is a double lattice, they are consequently in pairs, and the total sectional area of the pair is 12'38 square inches. The total

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The text discusses the design and calculation of a girder, including the determination of stresses and strains, the use of angle-irons and plates, and the calculation of cross-sectional areas. It also mentions the use of lattice girders and the importance of distributing loads evenly to ensure structural integrity and efficiency. The calculations and principles discussed are fundamental to the design and construction of bridges and other structures based on similar principles.
sectional area of the pair is therefore 15.36 square inches. Proceeding now from the same point towards the pier, all the ties, with the exception of the two nearest to the point of maximum strain, have the thickness of the bars increased to 1.10 in. The sectional area of the two outer bars is 21.35 square inches. The two exceptions are of the same scantlings as the lightest section used at the other part of the web. The channel-iron struts have the same breadth as the bars, and vary in section in proportion with the ties they cross.

They are considered to be also strained to the same amount respectively, but the tie plating is that of the strain to 21.35 square inches. Hence in the sectional area is proportioned so as to be one-sixth stronger than that of the corresponding intersecting ties. The heaviest section of used in this girder is $9 \times 8$in. $\times 3 \times 4$in. $\times 0.6$in., giving a sectional area of more than 12 square inches. The general formula for the strain upon a pair of end bars is

$$S = \frac{2 \times N \times \sin \theta}{W}$$

where $W$ is the total load distributed, $\theta$ the angle between the bars and the horizon, and $N$ the number of systems or series of triangulations in the web. As, however, the load in this instance is not uniformly distributed, and therefore not transferred in equal portions to the supports, we must substitute for $W$ its two values of $R$ and $R^1$ already found.

Following the same order with the strains as in describing the bars, and bearing in mind that the reciprocal of $\sin \theta$ is $1 + \frac{2}{3}$, we shall find the strain upon the last pair of bars over the abutment to be 64 tons. Dividing this strain by the sectional area of the bars, it will be seen that they are strained a little less than the stipulated maximum amount, since we shall have about 31 tons to 12 square inches. To find the strain upon the bars upon the other end, we must consider the position of the girder $V^9$, which is placed at about the distance of 1ft. from the pier. The weight brought upon the main girder at this point produces no effect upon the lattice bars, and, in fact, scarcely any at all upon that end of the girder, as the strain is practically taken by the pier. Refer to the table of weights, we find this load to be 143 tons, and it must be deducted from 350 tons, the value found for $R^1$, before that quantity be used in the formula for the end strain. Effecting this substitution, and solving the equation, we shall find the strain upon the pair of end bars to be 75 tons, and dividing as before by the area, the strain per square inch comes out the same as before, viz., 31 tons. The bars in the web of this girder appear to be proportioned scarcely so scientifically a manner as one would expect, nor is that due attention to the varying amount of the strains in every bar sufficiently shown. For instance, there is no change made in the sectional area of the eight bars, starting from the foot of the pier to the direction of the abutment. Again, when the section is increased, the remaining bars, six in number, are all of the same section. The principal point to be noticed is the excessive discrepancy between the two bars where the increase takes place. This, bar 7 has a sectional area of 128in., and bar 9 of 151 square inches, a jump of 31in. in area being made all at once. The discrepancy at the other end of the girder is still greater, the difference in sectional area of the double bar and being over 9 square inches. It would not be judicious to make the sectional area of the web of a lattice girder vary too closely with the strains, especially in a railway bridge, or whenever the rolling load is large compared with the dead weight, but it should be borne in mind that the web of a lattice girder constitutes its chief economy. If it is not designed in a correct and scientific manner, it would be better to put a plate girder instead, and there are undoubtedly numerous examples of lattice girders which would be much better done in the same positions. The cause of the jumps in the section of the bars is mainly owing to the very unequal distribution of the weight, and we will consider the respective strains upon the bars of equal section. The minimum strain upon the first eight bars mentioned is about 3 tons, and the maximum 32 tons. Upon the last two bars towards the pier is 30 tons, and the maximum 75 tons. There is clearly a great loss of material in constructing these bars of equal sectional area. As the rolling load in this bridge is little or nothing, there is no necessity for making the bars at the centre stronger than what is required for a dead load.

"Mosaic," said Ghirlandajo, "is the only painting for eternity." Some two thousand years ago it was practiced by Greeks and Romans, and now its revival is attempted by the Department of Science and Art at South Kensington. Processes which centuries ago were firmly established, revert once more to experiment, and an art all but lost has again to go through the successive stages of discovery. The mosaic pictures, eight in number, put up at Kensington, have received, for the most part, eulogy; and the experiment is so important and novel, that a critical description of the technical processes and the arts of design called into play may prove instructive. First as to process or material. The ancient methods are at Kensington translated with a difference. They may be, for example, composed chiefly of cubes of coloured stones or marbles. Our modern mosaics differ from the old in that they rely in no degree on natural substances. The cubes or tesserae at Kensington are entirely artificial, yet in chemical composition and art aspect they are not identical. The terms used to designate the varied material are "glass," "enamel," and "ceramic," otherwise "earthenware." Dr. Saltvati, whose name has been identified with the revived manufacture of Venetian mosaics, has (from cartoons) executed in the South Court, Kensington, the figures of Nicolo Pisano, Benozzo Gozzoli, Apelles and Giorgione, in materials termed "glass," and "enamel." And it is the work of the Saltvati process, now more laboriously attempted, according to two distinct materials, a semi-transparent glass, used as the basis of gold, and an enamel as opaque as sealing wax. It would put the matter on a true scientific basis were a careful analysis made of these tesserae. Will Saltvati, Minto, or Powell do this for their several manufacturers? Glass and enamel, however, have the liability that the surface glintens and gives off light, a quality which in turn has been deemed a merit and a defect. And here is the point upon which manufacturers diverge at the present moment. Certainly a polished surface gives greater brilliancy, and the picture when viewed at the right angle is seen at a further distance; for the same reason it remains visible in a low light approaching darkness. On the other hand, there are abundant disadvantages to which a dead or mat surface is not subject; such a surface is seen in the figure of Cinabres, wrought, both in figure and background, by Messrs. Minto, not in glass but earthenware. Certainly the picture is less obtrusive; it can be seen without dazzle at varied angles, and so far it approaches fresco. There is another figure, that of Hogarth, which makes a compromise between the two processes; the gold background is glazed, while the figure in material ceramic or earthenware is dead or mat. This discrepancy or contrast has been specially designed by Messrs. Simpson to give decorative brilliancy to the background, and at the same time to make the figure from distracting glare of surface. The experiment is believed to be novel in the history of mosaic art. Such improvements, indeed, as Constantine and his successors made in mosaics were all on the side of greater brilliancy; and specially is it recorded by Thophilius that the Byzantines discovered a cunning process of introducing a ground of gold under a surface of glass, whereby was shed over large mosaic works a splendour before unknown. This ingenious method, still to be observed in the mosaic pictures on the façade of St. Mark's, has obtained from Mr. Ruskin warm encomiums. And the delight of the imperial process is essentially skillful and scientific, by Saltvati. When the modern gold glazed tesserae are placed side by side with cubes from the façade of Orvieto Cathedral, no material difference can be detected between them. An unbroken gold background is all but an untried decorative condition in this country. But the middle ages afford a number of precedents which, however, by no means approach to the art of modern times, of Santa Sophia, and the ceiling in a staza of the Vaticans, painted by Raphael, in imitation of mosaics. In modern times, too, the Byzantine church of All Saints, Munich, shows a background blazing in brightest gold. For the direction of our own artists, it may be useful to recapitulate the conditions essential to the preservation of gold backgrounds. The earth is obviously non-natural, conventional, and decorative; the colour of the gold is intense, and requires corresponding lustre in the surrounding ornament. Such treatment necessarily implies architectonic and monumental styles. And these considerations enjoin simplicity of composition, severity in line, breadth and
firmedness in modelling, and decision in relief of figure from the plane of the background. Such canons, enforced by the exact and best example of the place, are the result of a position between bas-reliefs and paintings; and it is evident that the compositions at Kensington have been chastened and restricted accordingly. Indeed, even that degree of pictorial treatment usual to bas-reliefs subsequent to Ghiberti, seems to have been deemed inadmissible. It is true that the tenth and best example of the place, the school of Titian and Tintoret, are flowing and free; and it is said that in the Pope's manufactory in Rome, enameles of 10,000 different colours are used, so as to make the mosaic for St. Peter's vac-simile copies of the works of Raphael and the florid painters of the late Italian school. But such treatment, the least Neoclassic to the popular eye, 28 tons deemed out of keeping with architectural compositions. This judgment prevails at Kensington, so that only in some small accessory details is pictorial treatment seen in the cartoons, and the completed mosaics are in liberty further restricted, so that distance and perspective have been wholly excluded. In short, the treatment approaches that of the strict Greek bas-relief; in other words, the figure and action are limited to the one plane of the foreground. This is at all events safe; the practice is at least sanctioned by the best precedent; yet, in the words of Sir Charles Eastlake, the unfinishing application of these strict principles to all mural decoration were an "extreme doctrine." Doing less may be possible upon a more moderate scale by Mr. Krupp in two ways—first by means of a cup of steel, or copper, or even cardboard, that was inserted into the bore of the guns after the charge, or was attached to the end of the powder-bag. This cup, when the explosion took place, was expanded by the pressure, and completely filled out the bore of the gun, upon the same principle as the steam packing rings in pistons. This, however, involved the withdrawal of the cup each time the gun was charged, and therefore a second plan was proposed. In the face of the valve was turned a circular recess, corresponding exactly with the bore of the gun, and into this recess was fitted an angle ring, one face of which, when the valve was in its place, was in contact with the breech and the other face in contact with the side of the circular recess; so that when the gun was discharged, the gas entered the circular recess, and forced the two faces of the angle ring tight up against the breech and the side of the recess, and completely prevented the gas from escaping. The valve is kept in its place by a locking apparatus. This system has been very severely tested at Woolwich with perfect success, and has also been submitted to and adopted by continental governments, more particularly Russia. Guns up to 15 inch diameter of bore are made at Essen in very large quantities, but it would occupy too much space to enter into all the details of the experiments that have been carried out. The Austrian Royal Ordnance Company are now lining a great many guns with tubes made by Mr. Krupp. The Prussians generally attribute to those guns their signal successes over the Austrians in the late war, particularly in the decisive battle of Sadowa. The ponderous masses that have to be handled at Essen have rendered it necessary that the dimensions of the tools should be proportionately increased, and, indeed, this has now become essential, from the large ingots that are being daily cast. A short time since an ingot of 45 tons weight was cast, to form the material portion of a 15 inch gun; and to properly forge this even the 50-ton hammer is considered too small, as it entails much longer time, and causes the ingot to become imperfect. There is but little doubt that the steel-makers of this country are greatly indebted to Mr. Krupp for the energy he has devoted to the manufacture of steel, and its application to the variety of purposes. Steel is now entirely supplanting the use of wrought iron in those parts of machinery where great toughness, elasticity, and resistance to rusting are required. This is the new steel, which is used not only to the purpose of running on steel tyres, and the introduction of steel rails is becoming daily of more consequence. The steel produced at Essen is all well melted in plumbago crucibles, and formed into the ordinary ingot moulds, this process employing a large number of men. The large ingots of 55 to 60 tons and up to 1,000, 1,300 to 1,500, and 2,000 tons are employed at one time, occupying in the casting from eight to twelve minutes. The whole of the work, of whatever shape, that is turned out at Essen is made from these ingots, which are heated and forged until the desired density and form is attained.
THE RAILWAY SYSTEM OF GERMANY.

By ROBERT CRAWFORD.

(Concluded from page 339.)

PASSING on to the next point for consideration, that of earthworks, it appears to be a general, although not a universal, plan, in the case of all main lines, to prepare the earthworks and masonry for a double way from the first, but not to lay the second line of rails, until the success of the undertaking makes itself apparent, and the requirements of the traffic demand the additional way. Some of the smaller railways executed have been:—An embankment on the Southern State Railway of Bavaria, from Augsburg to Lindau, its greatest height being 172 feet, width at formation 334 feet, and length 1,675 feet, requiring upwards of 2,900,000 cubic yards of material to make it up. On the same line also occur embankments of great importance, two of which are respectively 84 feet and 35 feet high. On the railway from Augsburg to Ulm, there is a cutting 2,390 feet long and reaching to a depth of 90 feet; also an embankment 53 feet high, and 6,755 feet in length. Between Elberfeld and Dortmund occurs an excavation 96 feet deep, and upwards of 13 mile long; and on the same line there is an embankment 120 feet in height, with a length of 1,600 feet. Embankments from 75 feet to 180 feet high are to be found on the Westphalian railways. On the Bavarian State line, from Bamberg to Aschaffenburg, there is an embankment 100 feet in height at the highest point, and 1,743 feet long; besides two cuttings measuring in depth, the one 84 feet, and the other 71 feet, their respective lengths being 3,304 feet and 2,097 feet.

With regard to tunnels, the first executed in Germany was one 1,678 feet long, on the Leipzig and Dresden Railway. Besides the summit tunnel, 4,695 feet in length, on the Semmering Railway, already mentioned, there are many others worthy of notice, among which some of the most important are:—

A Tunnel 3,569 feet long at Königsdorf between Cologne and the Belgian frontier.

" 4,419 "  
Heiligenberg between Ludwigshafen and Bezbach.

" 3,695 "  
on the Saarbruck, Trier and Luxemburg Railway.

" 3,056 "  
Railway from Gewesungen to Carlshafen.

And a tunnel 3,057 feet long through the Schwarzkopf between Bamberg and Aschaffenburg.

This brings the subject to one of the most interesting of its sub-divisions, that of viaducts and bridges, which it is proposed to treat under two separate headings,—First, Bridges composed altogether of masonry, and, secondly, Iron Bridges. There are instances of large timber bridges such as those over the branches of the Danube, the Viennese, proportions of Ferdinand’s ‘Northern Railway,’ and that over the Elbe, at Magdeburg, whose superstructure only is of wood; but as these are cases of works executed in past years, and it being now laid down as a maxim by German Engineers, that timber is not to be used in railway bridges, it becomes unnecessary to devote space to the consideration of such works. To explain more fully these what anticipatory remarks, it may be well to introduce here, the views of the Associated Railway Directors on bridge building, as expressed in their code of rules. These are—

I. For bridges, arches of stone, or good bricks, are preferable to every other description of structure, except in cases which require very oblique bridges. II. Timber bridges are inadmissible. III. When iron bridges are made use of, the portion of the superstructure which sustains the roadway shall consist of either wrought, or rolled iron. Thus cast-iron bridges, as well as timber ones, are removed from the field of investigation. The former by negation, and the latter by direct condemnation.

Germany abounds in fine examples of stone viaducts and bridges of imposing dimensions and extent. It will be sufficient to adduce a few instances in addition to those already casually noticed, as occurring on the Semmering Railway. At the head of these stands the viaduct over the Goeltzsch Valley, on the railway from Leipzig to Halle. It consists of one central span of 93 feet, twenty-three spans of 46 feet in the clear, four spans of 39 feet, and two spans of 21 feet, one on each side of the large span through which may be called the abutment piers. Its greatest height is 255 feet, and extreme length 1,832 feet. The 93 foot opening has two arches one above the other, and on either side of it rise four rows of arches decreasing to one row at the ends. These additional arches are for the purpose of strengthening and supporting the piers, which carry the upper or main arches. All those in the upper tier are semicircular in form, as being the lower arch of the central span, while the others are segmental.

There is also another fine viaduct over the Elser Valley, on the same railway. It is formed of six semicircular arches of 98 feet span in the clear, three openings of 20 feet, and one of 19 feet. Two of the lesser openings have four pairs of arches in height, and occur on both sides of the arch which spans the deepest part of the valley. Two of the 93 feet arches are strengthened by a lower row of semicircular arches, and two others by means of connecting walls. This viaduct is, at its greatest height, 223 feet above the stream, and is 918 feet long.

The Nusen Viaduct on the branch railway from Kohlfurth to Görlitz, in Prussia, consists of one row of semicircular arches, thirty in number, of which three spans have a clear width of 73 feet 1 inch, three of 61 feet 9 inches, five of 41 feet 2 inches, and eighteen of 30 feet 10 inches. Its greatest height is 153 feet above low water, and its length, inclusive of abutments, 1,553 feet (472.50 metres). The viaduct carries a double line of railway, and was occupied about three years and a half in its construction, having been begun during the spring of 1844, and finished in the autumn of 1847. The masonry composing it amounted to 1,173,200 cubic feet.

The result of a series of experiments, for the purpose of ascertaining the best description of concrete to be placed round the foundations of the river piers, gave the proportions most suitable for yielding a quick setting, hard concrete, at

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A stone bridge over the Elbe, on the Junction Railway, at Dresden, is well worthy of notice. It consists of twelve basket-handle arches of 93 feet span each. The width of the roadway is 60 feet, one half of which is applied to the purposes of an ordinary road, and the other half to those of the railway. Its height is 97 feet above the river at summer level. One approach to this bridge is formed by a viaduct of forty-four arches of lesser span.

A bridge over the Roeder, on the railway from Dresden to Görlitz, consists of one arch 148 feet 8 inches wide. As a sample of an ordinary bridge of modern date, although not very large, it may be mentioned that over the Neckar, on the railway from Frankfort-on-Maine to Heidelberg. It is divided into seven equal spans of 88 feet 7 inches each, and carries a double line of permanent way at about 35 feet above the ordinary water level. Its building occupied from 1844 to 1848. The thickness of the piers at the springing is 10 feet 4 inches, or between one-eighth and one-ninth of the span. That of the abutments is 39 feet 4 inches. The width of the bridge between the outside faces of the masonry is 31 feet 6 inches, and the depth of the key-stone is 3 feet 11 inches. Comparing this latter quantity with the results to be derived from the different rules of eminent French authorities on bridge building, it appears that the depth of the key in the case of the Neckar bridge is somewhat over the minimum thickness required, both by Desjardin’s formula and by that of Gauthier. On the other hand, it is out of proportion to the huge thickness of the stone.”

By Desjardin’s formula for an arc of a circle = 40°.

\[ E = 0.02 \times \frac{r}{E_0} \times \text{radians} \]

where \( E \) = the thickness of the key, and \( r \) = the radius of curvature of the intrados in metres, which in the present instance is approximately 42 metres. Supplying this value, the expression becomes

\[ E = 0.02 \times 42 \times 0.90 = 1.14 \text{ metre} \]

By Gauthier’s rule for spans of 16—32 metres

\[ D = \frac{1}{24} \times S \]
where \( D \) = the depth of the key, and \( S \) the span in metres, and
\( S \) being 27 metres,
\[
D = \frac{27}{24} = 1.125 \text{ metre}.
\]
whereas in testing the matter by the method of Perronet it stands
\[
E = \frac{1}{24} D + 0.0325 \text{ metre} - \frac{1}{144} D,
\]
in which \( E \) = the depth of the key, \( D \) = the span, in the case of semicircular arches, but in segmental or elliptical ones, \( D \) double the radius of the intrados at the crown. Reducing this equation to a simpler form, it becomes
\[
E = \frac{1}{44} D + 0.235 \text{ metre}
\]
and supplying for \( D \) its value, 84 metres,
\[
E = \frac{1}{44} \times 84 + 0.235 \text{ metre} = 3.241 \text{ metres}
\]
or nearly three times as great as the thickness required by Gauthier's rule.

By comparing the practical example with the three calculated results, the following is obtained:

- The Neckar bridge, as actually built, has a depth of key = 1.200
- Ditto, according to Desjardins' formula, requires ditto = 1.140
- Ditto, ditto, Gauthier's ditto, ditto = 1.125

In the case of wrought-iron bridges the arrangement most usually adopted, when the spans are wide, is that of a lattice construction, in some one of its various modifications.

One of the earliest examples of importance is that of the bridge over the river Kinzig, at Offenburg, on the Baden State Railway. It is built for a double line of railway, with two projecting foot-paths on each side, and consists of three main girders one on each side, and two in the centre between the ways. There is but one span, its width being 266 feet 8 inches in the clear. The depth of the girders is 20 feet 7 inches, and they rest 13 feet 3 inches on each abutment. The top and bottom cross sectional areas of all three girders are the same, consisting of three thicknesses of iron laid one over the other, and forming together a plate 1/4 inch thick and 13 inches wide; in addition to which there are four angle irons 42 inches by 42 inches by 1/4 inch thick and one vertical bar, 5 1/2 inches by 1/4 inch, on the outside, running along the centre of the horizontal plates which form the top and bottom portions of the girder, to which it is attached by two of the iron angles, the other two serving to join the flanges to the bars which form the central web. This latter is composed of lattice-work, which in the case of the two outside girders, is formed with two sets of bars, 42 inches by 1/4 inch, crossing each other at right angles, and inclined to the top and bottom at an angle of 45\(^\circ\), the distances of the crossings apart being 1 foot 6 1/4 inches between the centres of the rivets measured along the bars. The central rib of the middle girder, between the ways, is stronger than that of the outside ones, inasmuch as it consists of three sets of bars, two of which are 1/4 inch thick and 1/8 inch, all having the same width as the other lattice bars. Along the whole length of each central rib there are two horizontal rows, formed of double rails of the bridge pattern, one on the inside and the other on the outside, and riveted to the lattice work. These rows occur at distances of 3 feet 11 1/4 inches and 7 feet 2 1/4 inches respectively below the top and above the bottom of the girders. The roadway inside and the projecting foot-paths are supported by transverse trusses, at intervals of 6 feet 3 inches apart, formed of ordinary flat-based rails, and the entire bridge is connected above and below by a system of cross and diagonal braces. The clear width between the outside and the central girders is 12 feet 8 inches. The abutments are surmounted by handsome ashlar portails in red sandstone. The weight of cast-iron in the bed plates is 23 tons, and of wrought-iron about 322 tons, distributed thus:

- Weight of central girder = about 92 Tons.
- Ditto, two side girders (together) = 148
- Ditto, cross girders and forehead braces = 82
- Ditto, upper connecting bars = 22
- Ditto, handrail for footpaths = 7

Total wrought iron in bridge = 322 Tons.

From this short description it appears, that the arrangement of the material is not a judicious one, considering the nature of the strains arising from the weight of the bridge itself and any superimposed load, since,—I. the dimensions of the ironwork are uniform throughout the length of the span,—II. Although a stronger lattice construction is adopted in the case of the central girder, still its top and bottom sections are of similar dimensions to the outside ones; and III. the cross sectional area of the iron has not been properly proportioned to its different powers to resist compression and extension, where these forces act.

Passing on from the consideration of the first of these undertakings on an extensive scale, the largest work of the kind yet executed in Germany naturally presents itself. This is the bridge on the Eastern Railway of Prussia, over the river Vistula, at Dulsau, consisting of six spans, 397 feet 4 inches in the clear. The depth of the girders is 38 feet 9 inches, and the height of their undersides, above the ordinary water level, is 34 feet.

The arrangement is for a single line of railway, but the width is 20 feet 7 1/4 inches in the clear, and the rails are laid along the centre. The foot-passengers are suspended on cantilevers on both sides. The iron work of each two spans is distinct in itself, being fixed on the pier at its centre, and moving on rollers at both ends. The system on which the iron work of each of two girders, one on either side of the roadway, held together above and below by a series of diagonal and transverse braces, in both the vertical and the horizontal planes. The girder top consists of four horizontal tiers of boiler-plate 2 feet 6 5/8 inches wide, placed one above the other, at distances of 2 feet apart, and made fast to a central vertical web, by means of angle irons; and similar angle irons are rivetted below each of these horizontal plates along their outside edges. The bottom section consists of an ordinary boiler-plate girder 4 feet 1 1/2 inch deep, with two flanges 4 feet 6 inches wide; the bottom of which has two thicknesses of plates 40 inches along its outer edges, while the top consists of a single plate. The solid top and bottom sections of the girders are connected by means of a lattice frame, consisting of two rows of bars inclined at 45\(^\circ\) to the horizontal, and crossing each other at right angles, at distances of 1 foot 6 inches between the rivets, measured along the bars. This is again strengthened by double angle irons 6 inches by 4 inches by 1 1/2 inch by 1/4 inch thick respectively, arranged vertically, one inside and the other outside, and rivetted to the lattice at horizontal distances of 6 feet 2 1/2 inches apart. At these points also are attached the cross-girders of lattice construction, which support the roadway at a height of 6 feet 2 1/4 inches above the top of the bridge. The thickness of the boiler-plate in the top and bottom sections is about 1/4 inch at the centre of the span. The lattice bars vary from a width of 42 inches at the centre to 5 1/2 inches at the sides, and 1 1/4 inch thick at the centre of the span, increasing to 2 1/2 inch at the movable end, which rests on rollers, and to 1 inch on the piers where the girders are attached. The bearings of the vertical angle irons are only half the normal distance apart, and the ends of the girders are further stiffened by solid plates. At the bearings furnished with rollers—that is to say, both abutments and piers Nos. 2 and 4—the breadth and depth of the top and the bottom sections of the girders remain the same as at the centre of openings; whereas on the other piers the lengths of the bearings rest immovably, the top is increased to 4 feet 4 inches in width, and all its horizontal plates are laid in double thicknesses of iron, while the bottom section, although retaining its regular width, is strengthened by doubling its depth by means of two corbels attached to the lower flange, the utmost of which projects about 40 feet from the top. The piers vary from the bottom 8 feet 5 1/2 inches wide. The whole of the material in the superstructure was carefully proportioned to the nature of the strains to which it would be exposed. The foundations for the piers were prepared by driving a number of bearing piles into the sand, at the rate of one every 18 inches square feet. The whole space was enclosed by a row of foot-piling 12 feet 6 inches square, driven close together and reaching to a height of upwards of 10 feet above the tops of the bearing-piles. The area thus formed, being filled up with the tops of the surrounding piles with concrete, furnished a bed of 10 feet in thickness on which the masonry rests. The foundations of the abutments were treated somewhat similarly to those of the piers, but they are not so deep.
The projections of the piers both up and down stream present sharp vertical arrises, or nearly so, from the water edge to the underside of the roadway. The facework masonry consists principally of basalt, with a small proportion of granite ashlars up to above ordinary water level. Above this hard sandstone is used, but only in the body of the piers. In the cutwaters the basalt masonry is continued for their full height. The blocks immediately under the road are of granite ashlars, the others being of basalt. The backing and filling-in is formed of hard burned bricks, and partly with ashlars, where greater strength is required, the whole being laid in hydraulic mortar. The piers are 32 feet 11 inches wide at the underside of the girders, and 82 feet long in the direction of the stream. On each of the masonry tower-like circular towers, one on each side of the archway, whose battlements reach to nearly 43 feet above the top of the girders. The abutments are surmounted by massive rectangular towers and a handsome connecting portal. The towers are all built with yellowish-white bricks, ornamented glazed ones, of a purple colour, being used in some of the moulings. The copings and principal dressings are of gray granite.

The general effect produced by this bridge, when seen from a distance, is very fine. The great depth of the girders reduced to some extent, however, the impression which would otherwise arise from the magnitude of the spans, apparently diminishing them to not appear quite so great as they are.

There is one point in which the Author thinks the ornamentation of this beautiful bridge is deficient. That is the crowded state of the relief over the pointed arch of the Dirschau portal, in which the field is far too small for the subject, and the upper moulding is brought down so close to the head of the principal figure, as to give the appearance of the design having been originally intended for a totally different position to the one it now occupies.

About 10 miles nearer to Konigsburg than Dirschau, and also on the Eastern Railway of Prussia, occurs the Marienburg Bridge, over the Otag, which is in reality another arm of the river Vistula. The bridge consists of two spans of 321 feet 8½ inches each, and two intermediate arches of 12 feet 6 inches in width, one at either end of the bridge. The roadway is for a single way, with a footpath on both sides, and is arranged for ordinary traffic similarly to the Dirschau Bridge. The distribution of the iron in the superstructure is, however, altogether different. The Nogat Bridge may be described as a compound, the whole forming one girders, or tube, about 23 feet in depth, of which the top and bottom are composed of ordinary boiler plates, and the sides of lattice-work, similar in principle to that already described. The cross girders which support the rails are of lattice-work 24½ inches in depth, and are placed at distances of 6 feet 2½ inches apart. At these same intervals, attached to the upper part of the intermediate Arch, at a distance of 6 inches from the top plates, are transverse bars, something in form like the letter Z, stretching from the lattice on one side of the roadway to that on the other. These ribs, as well as the keelsons below, are more securely made fast to the vertical rods by gusset pieces, which tend to stiffen the bridge laterally. In the space, 8 inches thus left between the cross of and the covering plates, six iron bars, also Z shaped, run longitudinally for the whole length of the girder, giving the top the appearance of a cellular form of construction in cross section.

As regards the nature of the foundations and the character of the masonry of these girders, they are not similar to those at Dirschau. The towers on the central piers are, however, rectangular in form, instead of round as in the latter case.

Both bridges have arrangements for mounting cannon, and other military precautions, at their ends.

The next example selected is that of the bridge over the Rhine at Cologne. This is a four river span, the four river spans each 324½ feet in the clear, and two equal land spans of 64 feet 10 inches width over the wharf and street on the left bank of the river. Two distinct bridges, one 89 feet 9½ inches in the clear, carrying a double line of railway, and the other, 27 feet 9½ inches wide, for the purposes of ordinary traffic, are placed parallel to each other, latter being used on the down stream side being used by the railway. The depth of the girders for the four large spans is 27 feet 9½ inches, and they are formed in separate lengths each extending across two openings. The clear height above low water is 50 feet.

The railway bridge is formed of lattice girders, double on each side. The top of the girders is 12 feet 2½ inches, placed one after the other, and close together, thus TTT, and the bottom has a similar form, but reversed. The lattice frames which connect them are 2 feet apart, and are tied together and stiffened by diagonal braces, placed vertically at every 5 feet 1½ inch. At the same intervals there are vertical angle irons, to strengthen the lattice, and keelsons to carry the roadway. Transverse angle irons and diagonal bars above are attached at every second top of the lattice bars. The lattice bars cross each other at distances of 2 feet 6½ inches apart measured diagonally. They are about 34½ inches by 1 inch at the centre of spans, increasing to 4½ inches by 1¾ inch, the ends resting on rollers, and to 6½ inches by 1½ inch at the fixed bearings.

The principle of construction of the bridge for ordinary traffic is similar to that of the railway, with the exception that the top and bottom sections are in shape that of a single T, instead of the lattice bars consist of a single lattice instead of double frames. Every second vertical rod is also composed of two angle irons, instead of one, laid together so as to resemble the letter E. The total weight of iron in both bridges is about 4,600 tons.

The foundations were formed of concrete, laid on the solid natural bed of gravel, which approaches close to the surface in the neighbourhood of Cologne. The ashlars masonry consists of basalt and sandstone, the former being used in the facework up to the underside of the girders, and where the greatest strength is required. The piers terminate in sharp upright cutwaters; that is, they are on the being and the upper. Their thickness is 20 feet 7 inches at the level of the girders. The ornamental portion of the design only includes towers, which are rectangular in shape, on the centre pier, and on both abutments. The approach to the bridge from the Central Railway Station in Cologne is effected by means of a viaduct of several arches, and by a bridge forming a sharp curve, whose radius, as already mentioned, is 618 feet.

The next case to be alluded to is that of the bridge across the Rhine, at Kerlargs, close to Strasburg. In cross section this bridge is somewhat similar to the Kinzig one, comprising two lines of rails with a lattice girder on either side, and in the middle, a line of track supported on the sides. The main portion of the bridge is that to which the lattice system is applied, and consists of three spans of 184 feet 8½ inches each. In addition to this there are two swing bridges of 210 feet in diameter, with solid wrought-iron plate sides, and opening a clear width of 85 feet 6 inches on each side of the river for military purposes, but less than those of navigation. The depth of the girders for the three principal spans is 19 feet 10½ inches, and the clear roadway in each case is 13 feet 9 inches. The lattice bars are inclined at an angle of 45° to the horizontal, and form a net work, the open spaces of which measure about 3 feet diagonal, and the keelsons are secured at their crossings by two rivets. The top and bottom sections are of the letter T; but they, as well as all other parts, are carefully arranged, so as to insure uniform strength for the bridge throughout, in proportion to the effect produced upon it by a load. The keelsons occur at intervals of 3½ feet, and are in direct contact with the rails, which are riveted to them. The lattice work is stiffened by vertical angle irons, fixed double on both sides, at distances of 9 feet 6½ inches. The iron work in the whole of the three openings is in one length, and is tied together above and below by a system of transverse and diagonal rods. The entire weight of the wrought-iron in the superstructure is 984 tons, or at the rate of 388 tons per span of 184 feet 8½ inches for a double line of railway. All the piers are ornamented with some Gothic ornamental work in cast-iron. Great difficulty was experienced with the foundations of the bridge, owing to the nature of the stratum of shifting sand which underlies the bed of the river at this point. They were eventually sunk to a depth of above 15 feet below low water, by means of wrought-iron cylinders, in which the masonry was built and afterwards the method adopted being that of compressed air. The operation of sinking the foundations progressed at the rate of about 20 inches per day of twenty-four hours.

In addition to these two bridges there is another now in process of building across the Rhine at Mayence, which is intended to be completed during the present year. It consists of the following spans:—

| Feet | In.
|------|-----|
| 32 | 4
| 331 | 4½
| 6 | 2
| 109 | 11
| 80 | 6
| 49 | 2½
| 984 | 2

32 spans in all, yielding a clear waterway of 3,134 feet.
The total distance between the abutments is 3,379 feet, and the heights of the underside of the girders above low water is to be 45 feet. The foundations are, like those of the Cologne Bridge, formed of concrete. The face masonry consists of red sandstone and ashlar, formed from the granite boulders found in the neighbourhood. The ironwork in the superstructure, which is for a single way, is very similarly arranged to that in the Sitter Bridge, modified in particulars as regards section, and the form in which the material is applied, according to what is known in Germany as the system of Professor Pauli, of Munich, which gives a rectangular top to the beam instead of an oval one. As a good example of Herr Pauli's system may be mentioned the bridge over the Saar, at Grosspetersbode, on the railway from Munich to Salzburg. It has four spans, two of 191 feet, and two of 965 feet, at a height of 1014 feet above low water. The Eastern Railway of Bavaria has also some fine lattice bridges, such as that over the Danube at Regensburg, having five regular spans of 165 feet 2 inches each, with iron superstructure for single way, and fifteen flood openings of segmental arches in masonry each 47 feet wide, all the arches being 3 feet wide; five of them are on the left and twelve on the right bank of the river. The height of the underside of the girder is about 33 feet above low water. The bridge was finished in 1859, and the weight of the ironwork in the five openings is 662 tons, or 124 tons per span. On the same railway, at the town of Passau, there is a bridge over the river Inn, with one span of 266 feet 10 inches measured on the skew, the angle between the axis of the railway and the direction of the stream being 71°, adjoining this opening are six stone arches, five of 47 feet in width on the left bank of the river, and one of 38 feet 3 inches on the right. The level of the rail is about 48 feet above low water, and the weight of iron in each of the five spans is 83 tons, for a single line of rails.

These few examples are sufficient for the purpose of illustrating the progress made in Germany in the construction of iron bridges on a large scale, and complete this portion of the subject under consideration.

Directing attention to the next branch, that of the permanent way, it appears that about seven-eighths of the rails in use are of the broad base or contractors' pattern; the remaining one-eighth being composed chiefly of chair rails, with a small proportion of the bridge-shaped ones. Fishplates, made fast with four screw-bolts, are now almost universally adopted, for connecting the ends of the rails, and they are always of the type of the sleeper, generally 12 inches by 6 inches, a wrought-iron chair-plate being interposed between the rail and the timber. The modern English system, of leaving the joint free without any sleeper under it, has hitherto met with but little favour from German engineers. A trial of this arrangement has, however, lately been made, on a short branch of the railway from Frankfort-on-Maine to Heidelberg, and the result has been so satisfactory, that it is intended to lay the entire permanent way of the new line about to be constructed from Gustsburg (opposite Mayence) to Frankfort, on this plan.

With regard to the size of rails, the rule laid down is that they shall not be less than 4 inches in height by 4½ inches in width of head, and that their surface shall be curved to a radius of from 5 inches to 7 inches. The general weight of rails now adopted varies from about 68 lbs. to 76 lbs. per yard, both these limits being passed in a higher and lower direction according to local requirements.

The following table of the dimensions and weights of some of the principal broad base, or contractors', rails in use on various lines will afford interesting information on the subject:

<table>
<thead>
<tr>
<th>Weight per Yard</th>
<th>Width of Head</th>
<th>Width of Base</th>
<th>Thickness of Rail</th>
<th>Height of Rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs.</td>
<td>inches</td>
<td>inches</td>
<td>inches</td>
<td>inches</td>
</tr>
</tbody>
</table>
| Dortmunder and Essener Railway | 60-70 | 24 | 3½ | 0½ | 4½
| Louise of Heise ditto | 65-75 | 24 | 3½ | 0½ | 4½
| Frankfort-on-Maine to Cassel ditto | 70-75 | 24 | 3½ | 0½ | 4½
| Ditto to Heidelberg ditto | 70-75 | 24 | 3½ | 0½ | 4½
| Ditto to Mainz ditto | 75-80 | 24 | 3½ | 0½ | 4½
| Frankfort-on-Maine to Wiesbaden ditto | 70-75 | 24 | 3½ | 0½ | 4½
| Hanoverian State Railways | 70-75 | 24 | 3½ | 0½ | 4½
| Bavarian ditto | 75-80 | 24 | 3½ | 0½ | 4½
| Prussian ditto ditto | 76-77 | 24 | 3½ | 0½ | 4½
| Raden ditto ditto | 76-77 | 24 | 3½ | 0½ | 4½
| Summering ditto ditto | 76-77 | 24 | 3½ | 0½ | 4½

The almost universal system of supports is that of cross-sleepers. They are generally of oak, when it can be procured at a reasonable price. Different descriptions of larch and fir are often used, after being prepared by some chemical process to resist the tendency to decay. Various are the means adopted for this purpose, but the one which is now most favourably regarded is that of forming a solution of sulphate of copper through the pores of the timber to be prepared. The most simple arrangement for carrying out this method is a tank erected on a wooden frame about 30 feet high, into which the solution is pumped from the tub in which it is mixed below. It is then associated with a man reaching within a couple of feet of the ground, when it diverges into two horizontal branches, with a series of small feeders about every 3 feet at right angles to the mains, and 10 inches or 12 inches long. On these are tied flexible gutta-percha tubes 8 feet in length, furnished at the ends with brass nozzles, and having screw clamps attached to them, by which the supply can be cut off from each separate feeder, without interfering with the others. The timber to be prepared must be round, with the bark on, generally in lengths of say, two sleepers. It is laid horizontally, on a rough supporting frame, and sawed across the middle, through about nine-tenths of its thickness. A wedge is then carefully driven along the middle line of the frame. This opens the saw-cut above, and admits of its being caulked round the outside edge with oakum. The wedge is next removed, and the cut closes up to a certain extent on the caulking, leaving a vacant space inside between its faces. Into this a slanting hole is bored from above, and the nose of the flexible tube inserted, and the solution allowed to flow into the centre of the tree, and acting by the hydraulic pressure from the high-level tank, it makes its way through the pores, forcing the sap out before it. When the wood has become thoroughly saturated, it is ascetained by applying litmus paper to the end of the stem. The clamping screw is then driven in, the piece of timber removed, to make way for another. The most advantageous number of stems to prepare at the same time with one apparatus is about fifty, a similar number being always ready to supply vacancies as they occur. For success with this method, it is necessary that the timber should be cut down when the sap is in it, and prepared while green, as otherwise it occupies too much time. Also, that the bark should be whole, to prevent leakage, and that the stems should be in duplicate lengths, so as to admit of their being prepared from the centre. The average time of preparing a log 18 feet or 20 feet long, under favourable circumstances, is about twenty-four hours.

The square stone blocks of considerable extent, as supports for the rails on the Taunus Railway, but this is only on the old permanent way, as they are not made use of on the new line of rails now being laid down by this Company.

In noticing ballast on German railways, there is a system frequently to be met with which can scarcely be passed over without comment; that is the filling up of the space outside the ballast to the level of the top of the sleepers with common earth, drains being cut through it at intervals, from the ballast to the outside slope, and filled up with broken stone. These drains, although at first answering tolerably well the purposes for which they are intended, after awhile become choked with the mud which is washed into them by heavy rains, and the free escape of water from the ballast is prevented. Add to this the mixing of the earth with the ballast, which is almost inevitable during repairs, and it becomes evident that the system has great drawbacks.

The stations on German railways are, as a rule, large and commodious, and in many cases display much architectural taste. They are generally close together.

The frequent absence of any description of fencing is also a marked feature on many German railways, the necessity for such a protection being done away with, inasmuch as cattle, excepting in some districts, are at large without being attended by a herdsman. This latter arrangement is rendered imperative by the minute subdivision of land, which prevents the practicability of enclosing each separate property.

The quantity and description of rolling stock in use on different railways in northern and southern Germany varies greatly. The passenger carriages have principally six wheels, but there are many lines on which four-wheeled vehicles are adopted. On
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December 1, 1865.

Wurttemburg State Railways, the long eight-wheeled carriages on the American system are in use. As nearly as can be estimated, the quantity of rolling stock at the close of the year 1861 stood thus:

<table>
<thead>
<tr>
<th>Engine Type</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locomotive Engines</td>
<td>4,194</td>
</tr>
<tr>
<td>Passenger Carriages (41.91 seats each)</td>
<td>157</td>
</tr>
<tr>
<td>Goods (average 91 tons)</td>
<td>7,404</td>
</tr>
</tbody>
</table>

Before any engine is permitted to be used, its boiler must be tested with hydraulic pressure to at least once and a half the maximum steam pressure which it is intended to sustain, and a similar test must be applied after the engine has run 461,109 miles, and subsequently repeated every time an additional 36,587 miles has been made, or whenever important repairs are required, should the test show any signs of weakness. The test must continue until between such testings exceed three years. On all such occasions the weight of the safety-valves is also proved.

With regard to the proper proportion of breaks to any train, the rule laid down fixed the minimum number according to the following scale:

<table>
<thead>
<tr>
<th>Number of Breaks</th>
<th>For Passenger Trains</th>
<th>For Goods Trains</th>
</tr>
</thead>
<tbody>
<tr>
<td>For lines with a maximum gradient of 1 in 500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(of the enumber of wheels to have</td>
<td>(of the enumber of wheels to have</td>
<td></td>
</tr>
<tr>
<td>number of wheels to have</td>
<td>number of wheels to have</td>
<td></td>
</tr>
<tr>
<td>breaks, have breaks</td>
<td>breaks, have breaks</td>
<td></td>
</tr>
<tr>
<td>1 in 300</td>
<td>1 ditto</td>
<td>1 ditto</td>
</tr>
<tr>
<td>1 in 200</td>
<td>1 ditto</td>
<td>1 ditto</td>
</tr>
<tr>
<td>1 in 150</td>
<td>1 ditto</td>
<td>1 ditto</td>
</tr>
<tr>
<td>1 in 120</td>
<td>1 ditto</td>
<td>1 ditto</td>
</tr>
<tr>
<td>1 in 100</td>
<td>1 ditto</td>
<td>1 ditto</td>
</tr>
<tr>
<td>1 in 80</td>
<td>1 ditto</td>
<td>1 ditto</td>
</tr>
<tr>
<td>1 in 60</td>
<td>1 ditto</td>
<td>1 ditto</td>
</tr>
<tr>
<td>1 in 40</td>
<td>1 ditto</td>
<td>1 ditto</td>
</tr>
</tbody>
</table>

When the rate of gradient exceeds 1 in 300, it is ordered that the last carriage shall be supplied with breaks, and another rule in regard to the arranging of trains is that, between the engine and first passenger carriage there shall always intervene at least one or more other cars. It might have been well, when, in the beginning of the year 1860, the passenger train at 7 a.m. from Eberbach reached the Bruchsal station, the last carriage to be considered under specific heads, of every detail of expenditure, and as these were published annually, the Companies, who were brought into a wholesome competition, for the reduction of the working expenses, to a minimum. Each Company was held up to "the test", that they were interested in the reduction of their respective expenses. A recent inquiry showed, that the expenses per train mile on two-thirds of all the German railways were within a fraction of each other. But notwithstanding the fact, he believed it was the case that the one and only railway company which was always to be considered of the cost of the railway lines, one-fourth only having two lines of way, was $16,000 per mile; that would amount to about $2,140 per mile in the single line. Now when the cost of land, the Parliamentary and legal expenses, and a vast number of other items which had unfortunately swelled the expenditure in this country were taken into account, he thought the average cost of the lines in this country must be much exceed that amount, particularly when of later date, those items of construction which did not fall upon the continental lines being of course eliminated.

The principle of railway legislation in Germany, as on the continent generally, was this:—The Government granted a concession for a railway from the town of A to the town of B, and sometimes provision was made, that it should run by way of the intermediate towns C and D, but all the roads were left to be determined by competitive tender. The evidence of individuals, in respect to the direction the line should go, was not taken, but the line being granted from point to point, the details were decided on the spot, where they could best be settled; and although it sometimes gave rise to considerable delay and annoyance, it saved vast sums of money. The same might be said as to the land. There was more trouble, perhaps, in getting land on the continent, but then it was obtained at the mere agricultural or mere town value. There was a number of cases to be considered a comparison between the cost of lines in Great Britain and on the continent. As a rule, neither the engineers nor the labourers were so well paid on the continent, and there were various contingencies besides; so that he really thought—and it was a question he had studied for many years—whether the wages were taken into account, the costs were obliged, in his own mind, to compare them with similar works executed here and elsewhere. The German system of construction was, in general, no more than adopting, in a greater or less degree, the plans which had been found successful in this country, with such modifications as the circumstances required; but their works would not as a rule bear comparison with similar ones in the United Kingdom. For instance, the viaducts built from the designs of Mr. J. Miller (M. Inst. C.E.), upon the Glasgow and Dumfries Railway, were works of boldness of conception and excellence of workmanship, and instead of following the old Roman fashion, of building tier upon tier of arches, as was the practice upon the continent, there was only one tier of arches, each pier being carried up to its full height without lateral support. With regard to the Direcbau and the Marienborg Bridges, it was unnecessary to analyze the principles on which they had been designed, because even from the descriptions given by the engineers of those bridges, and from the diagrams published with respect to those works, it might easily be shown that their mathematical construction was faulty, there being a want of due proportion between the several parts. He had watched the progress of these structures, and the reason which had ascended that their cost had certainly not been less than $56 per ton. It must be understood that this was not said by way of depreciation, because, he thought, considering the struggles that had taken place in Germany, the results were more than satisfactory.

He was exceedingly dissatisfied in speaking on this subject, for he had so much to do in Germany many years ago, at the time of the introduction of railways, that it was impossible to allude to that period without saying more of himself than, as commissioner, he had the railway from Bruckwitz to the foot of the Herz Mountains, then almost the first after the Nuremberg and Fürth line, he introduced that particular form of rail, of which the Author had properly stated that seven-eighths of those in use on German lines consisted, which was laid in this country, and it was better known in America and on the continent as the Vignoles' rail: it was a system which he studied very much, before finally recommending and adopting it. It was properly called the contractors' rail, because the contractors were responsible for the first line; the friend of the railways in Germany, and the cultivator of the German engines, was also a friend of the railways in England, and the public generally.

The great principles, which he thought ought to have been insisted upon, as characterizing the German system of railways, were the simplification of the permanent way, and the perfection of their statistics. All the railways in France, to give an example, were laid under specific heads, of every detail of expenditure, and as these were published annually, the Companies were brought into a wholesome competition, for the reduction of the working expenses, to a minimum. Each Company was held up to "the test", that they were interested in the reduction of their respective expenses. A recent inquiry showed, that the expenses per train mile on two-thirds of all the German railways were within a fraction of each other. But notwithstanding the fact, he believed it was the case that the one and only railway company which was always to be considered of the cost of the railway lines, one-fourth only having two lines of way, was $16,000 per mile; that would amount to about $2,140 per mile in the single line. Now when the cost of land, the Parliamentary and legal expenses, and a vast number of other items which had unfortunately swelled the expenditure in this country were taken into account, he thought the average cost of the lines in this country must be much exceed that amount, particularly when of later date, those items of construction which did not fall upon the continental lines being of course eliminated.

Mr. Vignoles said, he did not think the Paper should be designated as treating on the German system of railways, though it contained an interesting description of various railway structures, and there were a number of points which, when studied in detail, would be useful and instructive, although, unhappily, which were not good examples, long previously existing in this country, and of a character which, if examined, would, he believed, be found more interesting to the engineer. Many of the works which had been described he knew perfectly well; and while he gave due credit to the engineers of Germany for what they had done, he was obliged, in his own mind, to compare them with similar works executed here and elsewhere. The German system of construction was, in general, no more than adopting, in a greater or less degree, the plans which had been found successful in this country, with such modifications as the circumstances required; but their works would not as a rule bear comparison with similar ones in the United Kingdom. For instance, the viaducts built from the designs of Mr. J. Miller (M. Inst. C.E.), upon the Glasgow and Dumfries Railway, were works of boldness of conception and excellence of workmanship, and instead of following the old Roman fashion, of building tier upon tier of arches, as was the practice upon the continent, there was only one tier of arches, each pier being carried up to its full height without lateral support. With regard to the Direcbau and the Marienborg Bridges, it was unnecessary to analyze the principles upon which they had been designed, because even from the descriptions given by the engineers of those bridges, and from the diagrams published with respect to those works, it might easily be shown that their mathematical construction was faulty, there being a want of due proportion between the several parts. He had watched the progress of these structures, and the reason which had ascended that their cost had certainly not been less than $56 per ton. It must be understood that this was not said by way of depreciation, because, he thought, considering the struggles that had taken place in Germany, the results were more than satisfactory.

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The line might be politically, and perhaps in other respects, to the Austrian Government, commercially the speculation was a most unprofitable one.

In mentioning the railway between Cologne and Liège, the Author had not noticed the way in which the passage had been effected between the two countries. The principal works were in Belgium between Liège and Verviers, and up to the Prussian frontier. They were constructed at an early period in the history of railways, and abounded in roads of 4 feet 8 inches, that is 1.5 meters, and nearly 6 feet, should be adopted. Though himself a warm advocate for a wider gauge, he felt compelled under the then existing circumstances, to declare in favour of the narrow gauge. It was too late to adopt a wider gauge, and the cost of widening the existing railroads, if it were feasible, would be enormous.

The German lines appeared to be lower than was necessary. On the Rhine, the speed of the express trains was limited to 14 miles an hour in ascending, and to 16 miles in descending, gradients of 1 in 60. He was satisfied that speed might have doubled the speed of trains, and, in descending such gradients, it was quite possible, with ordinary breaks, always to have the train under control, when travelling at a much higher speed; and the only limitation in descending upon him was that of the 'in hand.'

When a train was obtaining the mastery, running ahead in fact, it was readily perceived, and there was a certain stage of progression which might be denominated the ultimate speed which a train attained, after the speed had been got to a proper height, would not, by any decrease, or increase, lessen a given part of the line, or the falling of dews, intervened to give more sliding way. The late Mr. Robert Stephenson used always to complain of the cost of going up those heavy inclines; but Captain Moorsom believed that the cost of working up the line itself, at 28 miles an hour, was practically no more than going up the land. Besides, the railways, when made, were not subject to the same competition as in England.

Allusion had been made, in the Paper, to the railway over the Rhine. In this country, the lines were in a few cases, a few hundred yards wide, 500,000 cubit yards. The lines in Germany were in the middle of the country, and as the cast-iron was completely ignored. Now, he thought there were many cases in which cast-iron was exceedingly useful for bridges; and though that material might be open to some objections, yet it had the merit of being in the form of any given shape, and in the hands of admissible examples on railways in England, he could not agree in the conclusion which had been arrived at by the German engineers. The viaducts on the Summering Railway were constructed with intermediate arches of 22 feet 8 inches, and 48 feet 6 inches, in the middle of the country, and those upon the Rhine and Danube Railway had already been referred to; but in many parts of Lancashire, there were viaducts more than 100 feet in height, and he had built viaducts over 110 feet in height, without the intervention of intermediate arches. Comparing the general designs of these viaducts, he appeared to him that those on the Summering Railway contained more material than had been introduced into viaducts in England.

Captain Moorsom remarked, with reference to the whole cost of the German lines of railway, that they appeared they were laid down generally with the earthworks and bridges to receive double tracks eventually, but almost invariably waiting for the double track till the traffic should justify it. He thought a useful lesson might be taken in that respect in this country. He felt that there must have been many instances of the Government Inspectors, in which it was noted as a matter of unfavourable character, that land had not been purchased sufficient to lay down a double track on a railway branch where only four trains each way came from the main line. He directed the attention of the Inspector, but still it showed one of the impediments thrown in the way of economy in this country, as compared with the German system. He was at a loss to understand why 'The Association of German Railway Directors copied their Directors,' and he was told only a very few, and from the projective reported by the Inspector, but still it showed one of the impediments thrown in the way of economy in this country, as compared with the German system.

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There had been mention of the latitude of railways, and of the lines of 3,600 feet, and 4,000 feet, 2,000 and 2,500 feet for hilly country, and never less than 600 feet. He was prepared to say, that curves of 300 feet radius might in some instances be desirable. Not that in England such curves had been found, but to carry with it, and to carry with it, he thought it was in all cases of 300 feet radius, if necessitated by the circumstances under which he was obliged to lay out a railway, as he believed it would be possible to work round such a curve, to the satisfaction of the locomotive superintendent, at a speed of 20 miles or 30 miles an hour. Some years ago, he laid down a curve upon a radius of 7 chains, or between 400 and 500 feet, which remained to this day on one of the great lines of the kingdom. The trains were calculated to travel on that curve at 25 miles an hour; but when the line went out of his hands, the Directors issued instructions not to exceed 15 miles an hour round that curve, by which instructions of course all the calculations for 25 miles were falsified. With respect to the limitation of gradients to 1 in 200 in level districts, 1 in 100 among hills, and 1 in 40 on mountainous country, he remarked that the character of gradients might be greater, or comprised a greater variety of form, as some countries seemed to be laid out for a certain class of gradient. Thus, in the West of England, the land was laid out for 1 in 60; and if in 17 or 1 in 80, were attempted, serious difficulties would be encountered. In other countries, the lands were more mountainous and hilly. Therefore, as the country seemed itself to design the gradient on which the railway should be laid out, to limit these gradients by the dictum of book, or tables, appeared exceedingly unduly possible.
The monthly meeting of the committee of this Association was held on the 30th October, when the chief engineer, Mr. Fletcher, made his monthly report, from which the following is extracted:—

During the last month 473 engines have been examined, and 631 boilers, as well as two of the latter tested by hydraulic pressure. Of the boiler examinations, 506 have been External, 54 Internal, and 19 External boiler defects have been discovered, 5 of those being dangerous, thus: Furnaces out of shape, 4; fractures, 5; blistered plates, 2 (1 dangerous); internal corrosion, 12; external corrosion, 16 (2 dangerous); internal grooving, 2; external grooving, 1; feed apparatus out of order, 1; water gauges ditto, 17; blow-out apparatus ditto, 13 (2 dangerous); safety-valves ditto, 5; pressure gauges ditto, 4; without feed back pressure valves, 32.

**STRENGTHENING THE MANHOLES OF BOILERS WITH MOUTHPIECES.**—The importance of strengthening the manholes of boilers with mouthpieces is shown by the fact that nine explosions, by which fourteen persons have been killed and six others injured, have recently occurred to boilers in which this precaution has been omitted. In each of these explosions the primary rent has started from the manhole, and although in some cases the pressure of the steam has been considerably higher than it should have been, so that the explosions have been partly attributable to excessive pressure, yet they have been materially promoted by the weakening effect of the unguarded manholes, while others have been entirely due to that cause. Particulars of six of these explosions have been given in previous reports; while those of three others will be found below. The weakening effect of unguarded manholes is not produced solely by the amount of metal cut away, but to a great extent by the action of the water. These are generally internal, and held up to their work by the pressure of steam, and all the bolts and nuts, suspended from arched bridges; and as the surfaces of the plates at the joint are not dressed smooth, but left rough, a considerable strain is frequently put on the bolts to make the joints steam-tight, especially when the cover does not fit the sweep of the boiler. Thus the action of the steam, combined with bolts, tends to force the cover through the manhole and split the boiler open. This is just the action that takes place. In some boilers it has been detected in an early stage just in time to prevent explosion, while others have been known to burst shortly after the manhole covers have been tightened with the usual amount of force.

The manhole mouthpiece is an external one, made of cast iron, and in the shape of a short cylinder, with a flange both at the top and bottom, the lower one being curved so as to fit the sweep of the boiler to which it is riveted, while the upper one is flat, and fitted with a cover, secured with bolts and nuts. Both the cover and upper flange should be faced up true on their joint surfaces, while it adds a finish to the work to turn them up on the edge, as well as to face the cover on the outside.
The equipment of the boiler was most defective. There was a large manhole cut in the top of the shell, measuring 17 inches long, 10 inches wide, and 4 inches deep, but there should have been, with a substantial mouthpiece, while the hole was laid lengthwise on the boiler, so that it had a very weakening effect. There was but one safety-valve, an inch and five-eighths in diameter, loaded with a weight which at the end of the lever gave a pressure of about 160 lb. per square inch, though it was found that the water was poured into the boiler with the weight not at the end, but midway. There was no steam-pressure gauge, and no glass water-tube, the latter having been broken some weeks before the explosion, and the boiler worked on without it, while there was no feed-pump or injector for feeding the boiler, so that this could only be done by letting the pressure down, when the water was poured in, or pipe leading from two or three tubes placed three or four feet above the boiler.

When the boiler burst, it gave way at the unguarded manhole just described, five rents starting from it, which ripped the shell completely open along the top from end to end. The explosion reduced the house to a heap of ruins, the brickwork and timber being scattered in every direction, and an adjoining street strewn with the débris, while other portions were thrown on to the roofs of neighbouring buildings. The manhole cover is reported to have been blown to a distance of 100 feet, and the safety-valve to have been thrown 50, while the boiler itself was thrown away; while, in addition, the owners of the boiler, who were their own fitters, were both seriously injured, one of them fatally so.

From the evidence given at the inquest, it would appear that though the boiler was tended by its owners, this was done in a somewhat remarkable way. In consequence of there being no pump or injector, they were in the habit of charging the boiler with a whole day's supply at one time; and as the glass water tube was broken, they ascertained the amount of water in the boiler by tying an iron nut to the end of a string, and letting it down through the safety-valve, so as to make a sound, stating that after twelve hours' work they still found water in the boiler up to its top in the boiler of the disabled engine gauge. A mechanic, who had erected the engine and boiler, said that when the steam got up to blowing-off point, the owners were in the habit of drawing the weight to the end of the lever, in order to confine the steam in the boiler, instead of allowing it to blow off. Two engineers, one of whom made an official report on the cause of the explosion at the order of the coroner, called attention to the weakening effect of the unguarded manhole on the boiler, the former stating that if the boiler had been intended for high pressure, the manhole should have been strengthened, and the latter, that he did not consider it safe at a higher pressure than 60 lb. per square inch. Both of them concluded, after examining the boiler, that the accident was due to the shortness of water, while one of them added that the boiler was laid down, in the first instance, for a much lower pressure than that at which it had been worked; and to admit of an increase, the original safety-valve had been removed, and replaced by the one upon the boiler at the time of the explosion. The jury brought in a verdict. "That the explosion was due to shortness of water in the boiler, and the generation of gas, which caused an over-pressure;" while, at the same time, they censured the owner for not having supplied the boiler with a steam gauge and water gauge; expressing, in addition, their disapproval of the practice of placing such boilers in thickly populated parts of the town, and entrusting their management to incompetent men, to the imminent danger of the surrounding neighbourhood.

There appears to be an invertebrate popular habit of attributing all explosions to shortness of water and the formation of gases, and it would have done more to prevent the recurrence of similar explosions if the jury, instead of launching into theory, had adverted their attention to the internal defects in the equipment of the boiler—such as the absence of any feed pump, steam gauge, or glass water tube, the very disproportionate load upon the safety-valve, as well as the weakening effect of the large unguarded manhole—and pointed out the importance of having boilers more efficiently mounted. It appears that the joint of the manhole was not turned, but all manholes and joints leading to the few days prior to the explosion, and as the boiler burst the first time it was set to work after the caulkings, it would seem as if the manhole then received its finishing touch, which is in accordance with the view previously expressed, that the mischief effect of these unguarded manholes is not due solely to the
amount of metal cut away by the opening, but also to the strain put upon the plates in making the joint. It was not actually proved in the evidence that the weight was at the end of the safety-valve lever when the explosion occurred, if it had been, and steam had been up to blowing-off point, viz., 160 lb. on the square inch, it would not have led to the rupture of a shell of so small a diameter as this one was, had it been fairly made and suitably equipped; so that it would not appear correct to attribute the explosion simply to excessive pressure.

This explosion must also have been accompanied by a more intense bluish flame and smoke, and also, that which due to defective boiler mountings, while it clearly affords an additional illustration of the danger of unguarded manholes, and the importance of having them all suitably strengthened with substantial mouthpieces.

No. 29 Explosion occurred on June 11th, to a small boiler of multitubular portable class, not under the inspection of this Association, and resulted in injury to two persons.

I have not had an opportunity of making a personal examination of the exploded boiler, but have been favoured with a photograph, as well as with particulars and sketches taken by an engineer on the spot, from which it appears that the primary rupture occurred at the crown of the outer casing of the firebox, the rent running in a longitudinal direction, and through the manhole, which was not strengthened with any mouthpiece.

The explosion is extremely similar to another which took place to a portable agricultural boiler when at work driving a threshing machine on the 9th of January, 1896, details of which were given for the consideration that this explosion No. 3. Although there was no evidence in either of these cases of there having been excessive pressure, the question has been raised in both since the explosions occurred. Indeed, in the first instance, an action to recover damages was brought by the owner of the boiler against the party to whom it had been let out on hire, on the assumption that the explosion was due to his having improperly screwed the safety-valve down. The desirability of avoiding this uncertainty, apart from considerations of safety, appears to me a sufficient reason for adopting the recommendation already given on previous occasions; viz., that the spring balances with which the safety-valve lever of portable boilers are usually loaded, should be fitted with suitable stop collars or ferrules, which would render it impossible to screw the valves down beyond a pre-determined pressure; added to which, all these boilers should have two safety-valves, one at least of which should be of dead-weight construction, and not placed inside the boiler, where it would be out of sight, but outside, and in position to be both above-board and accessible; while the constant recurrence of constant rents in boilers through unguarded manholes, of which the present explosion is an additional illustration, must be the apology for repeating the oft-reiterated recommendation, that all these manholes should be strengthened with substantial mouthpieces.

From September 22nd to October 28th, inclusive, the following explosions occurred:—September 25th—Ordinary single flue or "Cornish," internally fired, 7 persons killed, 2 injured. October 5th—Portable agricultural, internally fired, 1 killed, 7 injured. October 8th—Marine, 2 killed, 2 injured. October 9th—Portable vertical, internally fired, 8 killed. Total, 18 killed and 11 injured.

Not one of the explosions given occurred to boilers under the inspection of this Association. I have visited the scene of the catastrophe of the two that were most disastrous, viz., that which happened on September 25th, and resulted in the death of 7 persons, and the injury of 2. The explosion occurred on October 9th, and by which 8 persons were killed.

I am not able, however, to give full details, but may state that neither of those explosions arose from shortness of water or corroded plates. The first was an ordinary Cornish boiler, 4 feet 6 inches in diameter, and failed in the external shell at a point near the battle-nail, and after what the persons may have been a small vertical one, internally-fired, and most improperly equipped, having but a single safety-valve, whereas there should have been two, while the one with which the boiler was fitted was of a most dangerous construction. Also the manhole was not strengthened by any mouthpiece, and the boiler lies at the present time under the management of the same maker which has recently exploded with fatal results, so that it deserves serious attention. The details of both these explosions are important, and I hope to be able to give them at an early opportunity.

APPARATUS FOR SAVING LIFE.

The inundations that have recently taken place in France have shown how very necessary it is to establish a communication, by some simple means, between two points rendered inaccessible by the water. M. Gustave Delvigne has invented an arrow to carry a line that may be easily thrown over to such points under the most adverse circumstances. There are everywhere a great number of guns available, either muskets of the soldiers, carbines of the gar- deners or, bowfowling pieces. The average calibre is from 17½ centimetres to 18 centimetres. This arrow for the purpose of conveying a line, consists of a rod of wood 1-10 to 1-20 metre in length, and 14 to 15 millimetres diameter, upon a flexible and straight grained wood. At the end which rests on the charge a copper ferrule is fixed with a small pin, 15 to 20 millimetres in height, and half a millimetre less in diameter than the calibre of the gun. This ferrule thus forms a protection, a stop at the back of the arrow. In urgent cases this stop might even be made by a little rod driven through the wood. An arrow thus prepared would weigh 180 to 230 grammes. For a bowfowling piece, the barrel of which is shorter, the weight of the arrow is reduced by a third, and also the charge of powder. At the front of the arrow is placed a loop, formed by the end of a line of about 60 centimetres in length, firmly fastened by means of a slip or a ligature. At the middle of this double line two strong ligatures are made with fine twine, so as to form a ring clamping the rod tightly. In this manner the double line forms two loops of equal length on each side of the ring. Below and against this fastening a noose is formed with the end of a line of the proper size, with five or six turns tightly round the pole. Near the line to be carried is fastened to these loops. This line 100 metres in length, and from 2½ to 3 millimetres in diameter, is wound on a conical mandril, which is taken out when the ball of line is completed, and the end within the ball is that which always should be attached to the arrow. If necessary the balls of twine sold by the rope makers, and which are easily unwound from the interior, may be used. This done, the gun or musket is then loaded with a charge of from 2 to 2½ grammes of powder (about half an ordinary charge), then two good wads of felt are rammed in, or else a strong paper wad. The arrow is then put in (the wood of which should be first slightly greased), and is well fastened down to the line. The gun is pointed at an elevation of 25 to 30 degrees in the direction required to send the line. In the firing, the fastening and the noose slide stiffly the whole length of the arrow as far as the projection or stop on the ferrule. By this means the inertia of the line to be carried is gradually checked, and the shock that would be liable to break the line is prevented.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

OPENING ADDRESS BY THE PRESIDENT,
ALEXANDER J. B. BERRISFORD HOFIE, M.P., LL.D., F.S.A.*

Having by your kindness been for the second time called to the chair of this Institute, I have again to open the annual session, and to review the position of the Society in regard to the noble craft of which we are the accredited representative within this realm. My task is, under one aspect, more easy than it was last November, because, from having been personally engaged in all the work of the Institute during the past session, I can speak with the confidence engendered by personal responsibility. On the other hand, that responsibility makes the second year's address a more difficult enterprise to him who has the honour to deliver it; for when he makes his first appearance he comes forward with something of the assurance of an invited lecturer; the second time, he appears as an official, bound to show for what he may have performed in behalf of the Institute during the past period, and to plead indulgence for all that he has neglected.

To begin with a purely domestic matter. I have to congratulate you upon the doubt which may have existed as to our right to prefix the word "Royal" to our style, having been solved by Her Majesty's gracious approval. For this, may we not view it as a further instance of the appellation. This session will be marked by certain alterations in our personnel, which are needed to give more efficiency to our work.

* Delivered at the Ordinary General Meeting, November 5th, 1896.
operations. It will not become me to say more upon this head than to assure you that, while fully convinced of the desirability of constructing the proposed two great towers, I have no desire at present of the world the example of so much done by a staff so nearly honorary in all its organisations.

Last November I referred to the relative functions of the Institute and the Royal Academy. The intervening year has been eventful for the latter body, for 1855 had not closed ere the claim of the Royal Academy for the election of Sir Charles Eastlake. Of the merits of that admirable man it is hardly necessary that I should speak to any who enjoyed the privilege of his acquaintance; but our transactions, I trust, penetrate beyond our own circle and island, and I should regret that this address did not contain our formal valediction of a man whose courage and endurance among the famous men whose praise is written in the history of British Art. The distinguishing characteristic of Sir Charles Eastlake's bearing, was a certain sweet and grave judicial evenness; kindly but firm, choosing with deliberation its time for speaking, and speaking then in the tones of one who claimed attention in right of his and his, and not of man so gifted, was of course eminently suited to be an efficient administrator in difficult times, and such were the latter days of the last President of the Royal Academy, Sir Charles Eastlake's place has, I am glad to say, been filled by the election of an Academician who has shown himself a vigilant sentinel of art, and who has given assurance that the principles which has put his courage to the proof. It is not many months since the attitude of art politics in regard to the Royal Academy and to the National Gallery was an object of anxious thought to all impartial bystanders. The late Government was desirous, to its credit, to diminish the long paralysis which had crept over the material future of the Royal Academy and of the National Gallery. It made its policy hinge on the expulsion of the Royal Academy from the building in Trafalgar-square, which was then to be transferred in its entirety, with something, to the National Gallery. The administration had not very long before advanced a different policy and proposed that the building in Trafalgar-square to the Academy, to build a National Gallery in the garden of Burlington House. The sincerity of my regret at the failure of this scheme will not be doubted, because Lord Palmerston's Government was induced to reconsider the proposal by pressure from the parties with which in political questions I am acquainted, but to follow and, to general politics. The edict of expulsion had gone forth, and a new position was offered to the Academy somewhere upon the site of Burlington House and of its grounds, on terms so lax as to involve either the destruction of its garden, which nobody wants to keep, or of the house and colonnade, which would have been a decided architectural lifeless, and feel a proved, for the preservation of that monument of eighteenth century architecture, but at the same time somewhat inexplicably as far as its own interests are concerned, the Academy, after a little hesitation, declined the Burlington site. Then there spread a rumour that a large area at South Kensington was placed at the disposal of that body on advantageous terms. The offer was undoubtedly liberal, and there might have been reasons for closing with it; but the scheme was obviously unpopular, because its essential element was the removal of the existing exhibition of modern pictures from the centre of bustling population to a spot which its best friends cannot deny is both solitary and, though not entirely inhabited, without the intervention of an unsuccessful attempt to induce the House of Commons to revoke the decision to which it had come in 1864, while, in the meantime, the Burlington House gardens site had been reduced by the cession of its northern frontage, lying between the Arc de and the Albry, to the University of London. Sir Charles Eastlake felt it and he had no doubt the site will have been obtained for the Gallery, with means of securing a magnificent façade towards Trafalgar-square. This opportunity of reforming the north side of Trafalgar-square, as I may notice by the way, is an advantage which would have been equally within the power of, and which would have been made compulsory on the Acts to bear. The House of Commons, it is important to note, is subject to risk making this the opportunity for raising a discussion on the comparative merits of limited or unlimited competitions. There is one stage in the discussion on which all who care for architecture must agree, and upon which this Institute made its formal stand when called upon to have an opinion in the course of the
discussion of last session. Those who support and those who oppose competitions, those who wish competitions to be unlimited, and those who prefer that they should be limited, must all agree that when a competition exists and is not unlimited, there has arisen a demand that it be limited. The objection has been, and is, that the undertaking being alike advantageous to the public, to the object in view, both in the stimulus to art which such a competition is designed to give, and in the good results of a building of which the city in which it is to stand and the nation may be justly proud. The competition for the Burlington Gallery has been, as we have said, the first that the number of competitors was to be limited to the number of National Gallery to the same limit.

Last year I had occasion to express my anxiety that the coming Palace of Justice might be worthy of its destination and of the empire. This year I can confidently say that the list of competitors gives the material guarantee that the building will fulfill the expectations of artistic patriotism, provided only the judges show themselves competent, and Parliament, in years to come, is wisely generous enough not to grudge the necessarily large sums requisite to bring so grand a work to its legitimate completion. I have, I feel, lingered somewhat long upon this subject. But it is one of so much importance, not only in regard to the buildings affected, but to the great question of the relations which ought to exist between architecture and the executive, that I have no reason to offer any apology for making it a prominent topic in this address.

I have now to call attention to the prospects of British architecture and of the cognate arts at the coming French Exhibition. The fact that I must of necessity confine myself to the Committee of this and other architectural societies which has, in my opinion, some form or other, come before almost every meeting during the past session. You know that, after many incidents, mainly traceable to the tenacity with which the French authorities, who are, of course, supreme, have, to this effect, determined to get for the French their share in the details of other countries, our committee has been recognised by the British Commissioners as the body on which it relies for accomplishing the Gallery of British Architectural Drawings in the Fine Arts Department (Group I), and also (though with a certain degree of official recognition) as arrangers of a Court of Manufactured Productions referable to Architecture and the Cognate Arts to be comprised in Group III. Our committee was disappointed at finding that we could only have allotted to us a space of 1,000 square feet in this third group. However the Ecclesiological Society obtained 700 square feet more, and by an amendment to the committee, the allowance for our committee was increased, so that we are exerting ourselves to make the best of what we have got. But out of these arrangements has grown a project of which I am grateful to say that we owe the suggestion to Mr. Cole, who promises to be alike useful and full of interest. The tale of designs which we shall be able to exhibit at Paris will be comparatively small, while the number we should desire to send will be proportionately very numerous. In face of this difficulty the South Kensington authorities have undertaken to arrange for us a preliminary exhibition in London, commencing at the beginning of December, in the spacious range of galleries at South Kensington, which were during last summer, and will again, it is hoped, be used as the temporary Portrait Exhibition. The space is vast and the time convenient, and so we anticipate the opportunity of bringing together a mass of contemporaneous architecture such as has never before been put in the power of the English public to study. Those who hope to appear at Paris are invited to confine themselves to certain designs, and promises not of small importance, that they desire it to be known that they do not regard this exhibition as a mere tasting for Paris, but as one possessing a national character and scope of its own, and which therefore need be only limited by the space at their disposal. It will, it is expected, contain many designs tendered for Paris, and it will also embrace designs sent to be viewed in London. A comparison of the list of the Institute, as it stood at the close of last session, with that of the year preceding, will show a considerable increase in the section of Honorary Fellows. I think we ought to regard this
circumstance with satisfaction, not so much for the material advantage which it is to our body, but for higher considerations, on the opinion not to be divested, but lost, that this chair, I myself belong to that order. What is an honorary fellow? Technically and literally he is the partner in a bargain, of mutual convenience to himself and to the Institute. Morally, however, we may, I hope, see in every new honorary fellow a fresh convert to the importance of our noble profession, a brother of the cloth in the concern of all and every building, science and art shall bear their due proportions. It is no doubt the duty, as it is the interest, of the architect to please his employer, so far as he can do so without sacrifice of self-respect. It is equally his duty to see that he is respected by that employer, in the same way and for the same reasons that the lawyer or the physician is, because to them the requisites that the architect’s technical knowledge carries with itself the guarantee of successful results unattainable by untrained cleverness. Now then, although a little learning is a dangerous thing where the half-taught empiric himself sets up as a practitioner, it is not dangerous in the hands of the man of sense, who is satisfied to appreciate and not to practise. On the contrary, it enables him to understand the value of things which are as sealed books to the wholly un instructed. Applying this truth (I fear I should say this truism) to our own case, I contend that it is for our direct benefit that the knowledge of the general principles of architecture should be as widely diffused as possible. The other day the editor of the Architectural Review was engaged in talking on the subject of the abominable state of the young mind, and, after a short though spirited period of independent existence, it succumbed to an arrangement which it would have been Quixotic, under all the circumstances, to have flouted, but which from the first has proved a source of numberless complication. You need not be told that this was the morganatic alliance which the Architectural Institute made with the South Kensington Museum, whereby, in return for house-room and certain privileges, personal and financial, the private loan of its property to the public institution. Of this connection with the South Kensington Museum I have no desire (as an officer myself of the Architectural Museum) to speak in any other than grateful terms. There have been from time to time rubs, but we have met with a great deal of kindness and much material assistance. Still the alliance was one which carried within itself the seeds of failure, except upon one condition, in which indeed I never could see any antecedent or theoretic incongruity, but which, then, first to last, through many accidents of negotiation, passed into every conceivable phase of practical impossibility. It seemed to us that—as the South Kensington Museum was expanding into a wide miscellaneous national collection of objects, both of scientific study and of art demonstration in its widest signification, divisible into many branches, and respectively staffed by men of high academic standing—the Government (which assumed the direct control of the whole institution) might relax its bureaucratic grasp of one of those branches, and leave it to be administered, under due inspection, within the walls of the new Museum, by a private corporation. In the Council of the Architectural Museum a body of men existed, willing and able to become the curators and directors of a national collection of architectural art, while towards making up that collection both the South Kensington and the Architectural Museums were stakeholders of valuable materials. From the very first, however, my Lord’s of the Committee of Council turned a deaf ear to any such suggestion. They were anxious, as they told us, for an Architectural Museum. An Architectural Museum! The concept of the great collection, whose name is borrowed from the suburb in which it has been placed, but the whole administration of that great and varied collection was to be, like the French Republic, one, indivisible and bureaucratic. They were ready to house the Architectural Museum casts, and to decorate those casts with the appropriate trappings. But we were to surrender them on loan. Of this condition of things, difficulty was of course, with the most friendly intentions upon either side, the inevitable result. The vital powers of the Institution—its capacity of growth—were smitten with paralysis; for how could it even procure fresh specimens, when on the one side we were being taught to believe that what we received by our hosts; and on the other, whether those hosts might not themselves be intending to take the same casts, to the saving of our own private purse. The result, however, is that while our individual casts continued, for many years, to do good duty as models for study at South Kensington, they did
so not as a valuable and distinct constituent contributed by private enterprise, but as scattered fragments of the general amalgamation of noticable objects. The hearts of its real proprietors were chilled towards the collection in itself, while with a genuine anxiety to hasten just the Museum's completion, and to these contributions they were inviting, they actually resolved the Museum, while still retaining its now somewhat incongruous appellation, into a committee for providing popular lectures at South Kensington on architectural subjects, and for stimulating the zeal of art-workers by annual prizes. The lectures, amusingly enough, were very miscellaneous in subject and treatment, and the audience comprised members of most diverse social classes. Accordingly they did much unsystematic good, in cultivating art-feeling, alike among the easy and the working members of the community. The prizes, also, which ranged over every description of art-workmanship, have, upon the whole, decidedly tended to raise the working-man's standard, and to consolidate personal intercourse between employer and employed, though more than once the particular result of the year's competition has been a disappointment. Such has been the so-called Architectural Museum, in the days of its intimate connection with South Kensington, a day-place; and when the collection goes, and the society has for itself secured an advantageous site whereon to build its own abode, close to Westminster Abbey. The lectures and prize giving may or may not be still continued at South Kensington, supposing the body to maintain its independent constitution; but for all practical purposes, the Architectural Museum, or by the valiantly abdicating a separate existence, if only some more powerful institution could be found willing to undertake the various duties which it has hitherto discharged. It is. I suppose, no secret in this Institute that a conference necessarily informal, was held during the late session between members of our council, and representatives of the Museum, to consider whether the Institute could not so far expand its organization as to cover the ground from which the Museum might then gracefully retire. This conference did not meet with the intention of coming to any definite resolutions, and it therefore deliberately with freedom, and broke up. I believe I may say, with the general idea that there was nothing impossible about the project—provided only that due care were taken not to hamper either the general funds or the chartered functions of the Institute by new and voluntary responsibilities. It would be clearly to our own credit and dignity, and to the advantage of architecture, if we were the first to open the way and vindicating the theatre no less than the church as a legitimate object for Gothic treatment; at the same time I conjure the competitors to consider seriously how they may reduce the risk of fire.

Another of our prize subjects was suggested by the proximate meeting, of which I shall have something to say further on, of the Architectural Institute in London. It is the restoration of old St. Paul's Cathedral. The materials for the competition will, as all our students are I trust aware, be found in the Vigorous engravings with which Hollar illustrated Dugdale's History of that cathedral. In them enough is given to provide the key to every portion of the church, as it existed in the days of Charles I. and the Commonwealth, but no one feature is depicted with an attempt at what we recognise as architectural accuracy, while the structure itself that is exhibited is St. Paul's after generations of neglect, and the destructive restoration perpetrated by Inigo Jones. Enough, therefore, exists to give sure guidance, and not enough to reduce the work of the sagacious and erudite student to the servile labour of a simple copyist and compiler. It would be I am certain, a great satisfaction to the Institute, if any set of designs were sufficiently good to justify it in advising their author to publish the series, and thus bring back to the minds of our generation the details of a minster, which, as I believe, from its noble length, the solemn Norman of its nave, the lofty and richly enriched choir, and the proportions which the English system of a square east-end was carried out must have been more like Ely Cathedral than any other of our known great churches.

The recollection of Old St. Paul's naturally leads to the general question of the destruction of ancient monuments, which we have wisely and boldly claimed as a portion of our stated mission, by the appointment of a committee specially charged with this
But I turn to a more agreeable topic, and I invite you to re-
record your gratification at the commencement of a work of
restoration which, alike for the beauty and value of the structure
itself, and for the national character of the enterprise, deserves
especial commemoration. You will anticipate that I am speak-
ing of the Chapter-house at Westminster, and will not require
any amplification on the subject of the cheerful
unanimity with which the House of Commons recognised its
responsibility towards the chamber, in which for more than half
the existence of that august assembly, it had been wont to
gather, must be noticed as an eminently interesting. For anti-
quity of the English people hold fast. To Dean
Stanley, who, in his typically thoughtful and perceptive
statement, must be credited the tribute of our hearty thanks
for their substantial good services. It was pleasant to
observe that when once the squalid fittings intruded into the last century
for the use of the public records had been removed, and the
vestiges of the Chapter-house stood out again revealed, so much of
the old work should have been found to be either still existing,
or traceable from sufficient indications. Mutatis mutandis as
the chamber was, it proved to be essentially the Chapter-house of
Westminster, and not any modern trespasser run up within its
walls. Accordingly the restoration is a matter of plain and easy
architectural induction, while no doubt, Science would exercise a
tender care and a conscience, but in his estimation of the very stones
and carvings of the thirteenth century, where the votaries of
the French school of clean and perfect sharpness would have
ruthlessly substituted that which we should have been compelled
to accept as modern fac-similes of originals smashed up in the
mason’s yard. It is interesting to recollect that the Chapter-
house was cleared out just in time to enable its appropriate
house-warming to take place, in the meeting there of
the Archeological Institute to listen to the lectures of the Dean of
Westminster, and of Mr. Scott, upon the Abbey.
I ventured last year to forecast the London Congress of the Archeological
Institute as one of the matters which I ought to introduce to the
body in the course of the coming session. I am now rejoiced to report
not only that the congress showed itself to be a most valuable
incentive to the philosophical study of architectural archaology,
but that it afforded the occasion for an extremely gratifying
fraternization between our own body and the Royal Archeological
Institute—two societies whose common wish for a
close alliance between them was plainly a thing to be sought and
enjoyed.
I must not close without repeating the regret which we have
already expressed at the sad and sudden death of our very
distinguished honorary member, Dr. Whewell, late master of
Trinity College, Cambridge. He was only a year of the
seventeenth century, and in its woodwork one of that English
continuation of Cinque-Cento, which is usually known as
Jacobean, has also been rescued from the destroyer, and will, I
am sure, in the hands of Mr. Norman Shaw, present a true
example of conservative restoration.
Another question, involving as it has done a matter of pro-
professional practice, as well as of the preservation of a very
valuable ancient monument, has been taken in hand by the
council. I mean the treatment by the Corporation of Bristol of
the prize designs by Messrs. Godwin and Crisp for the new
Assize Courts of Bristol, and for the preservation within them of the
old silk cotton mill. I hope that some day we shall have the
treatment of preservative against the repetition of such scandals as have dis-
credited that and other competitions is that more general
acquaintance on the part of the public with the principles of the
architectural profession which I have already had occasion to
advocate. So long as the arrogance or greed of the patrons of
any competition finds itself supported by the uninstructed public
opinion of persons who have never yet really learned to treat
architects as gentlemen or men of sense, so long will the scandal
continue. I would give the architect his true status, and
then he will find himself the master of public opinion, not its
enemy. Might it not be worth our while to publish some paper
bi-monthly into the general English newspapers to give it insertion, and clear enough for
everyone to understand, in which we lay down certain general
rules of competition, outside of which no architect can compete
without losing caste, and no patrons institute a competition, and
be able then to say that they had acted with fairness and
generosity?
also to pass into the category of public parks, from being transferred from the Office of Woods and Forests which only regards the financial value of its trusts, to that of Public Works, which deals with them for the general recreation and the decorative improvement of the ground.

At last the navigation of the River Thames has been reformed, whether efficiently time will show, and also, I hope, rectify any improved efficiency. Beneficial as this reform is to the world at large, it carries with it a special advantage to architecture, as it will render possible the vast system of metropolitan improvements which turns upon the quaying of the river, about which we have all no doubt thought so much, and will have no doubt still to think a great deal more. Let me in passing congratulate the Metropolitan Board of Works on having laid the first stone of the Southern embankment. One bill received the Royal assent, to which I should desire to call particular attention, as the first step towards the long-called-for opening between Whitehall and the Palace and Abbey of Westminster. This act only deals with the one wedge-like block, in front of the New Foreign and India Offices, whose apex is the Irish Office, but in this case the proverb about the point of the wedge will, I trust, receive its literal as well as its metaphorical interpretation. I refrain from recapitulating single buildings: but it is as well to reflect, with regard to the stages of progress; but the grandiose rebuilding of an entire quarter of the town by the Marquis of Westminster deserves especial commemoration. I gave reasons last year why I regarded our architectural future with hopefulness; to those reasons I am able to pledge my continued and increased confidence. It is not possible and no longer necessary, I hope, for our country to look abroad to foreign countries, either in the matter of the stonework of our churches, or in the display of the world, which is so largely our debtor, can check the architecture of Great Britain in its onward course of great and rapid improvement.

Mr. M. Diony Wyatt expressed the great pleasure which he and all present must have derived from the President's admirable address, developing the features of the architectural movement going on around them. It was in the confidence of a multitude of different circumstances tending towards the general purification of taste in this country, that the professors and practitioners of architecture might look forward with most confidence for the improvement of the art to which they were attached. On the part of some from congenital individuality, on the part of others from religious influences, and on the part of a third section of devotees from dilettante or archaological promptings, there was an active, combined, and harmonious movement towards the general advance of art now going on in this country of the most auspicious character; and it was due to him. It is possible that these efforts of all these elements were conducting to the common end which they all had at heart.

Mr. James Ferguson, V.P., thought the President had dealt with the main subject of interest of the day in a masterly manner, and that architectural art was attracting attention, not only amongst architects, but throughout the nation at large. People were no longer content with churches or dwelling houses of plain walls, pierced with holes, but ornamental art, and a certain number of architects formed the jury. There to appreciate, and men to demand, and that combination took place, progress was inevitable. With progress we would very soon be independent of Gothic, Greek, or any other style of art: the public seeing and learning to appreciate what was good would demand it and no longer be content with mere copies of extinct styles. He had no doubt the next ten years would witness such progress in architecture as would make it worthy of the nation and of the world. In that sense he felt grateful to the President for the way he had favoured them with.

Mr. George Godwin, F.R.S., was happy to re-echo one of the practical points which arose from the President's admirable address. It was with reference to the coming competition for the design of great public buildings. He looked with the greatest anxiety at the nature of the Committee which had to decide upon those designs. It was a most important point. Parliament would not meet before those designs were sent in: whether it would meet before the adjudication upon them took place he could not say. Therefore efforts through other channels were unnecessary: there was no necessity for any attempt to influence the committee. It was no longer the question of three or four amateurs—whether noblemen, honourables, or simple members of Parliament—to judge of the merits of such designs as those which were going in. Such, of course, could only produce what he himself had always lamented in his own country. They had but to look at the constitution of juries on such matters in France. A certain number of literary men, a certain number of painters and sculptors, two or three men of intelligence representing the public, are a certain number of architects formed the jury. There was seldom any question as to the decisions of those juries; and with that fact before them, coupled with the further fact that almost every adjudication on public art-works here did disappoint the public, it should lead the ruling powers to appoint a proper jury in which the country would have confidence. He was therefore anxious that some course should be taken to appeal to Mr. Cowper. He believed Mr. Cowper was a good member of the Committee, and it was impossible for a certain number of gentlemen for whom he had the highest respect, but to commit to them the final decision upon the plans for the National Gallery and the new Palace of Justice, could only ensure a failure. The present committee should be dismissed to the right quarter, seeking for a proper jury to adjudicate upon this matter. On this subject he hoped he expressed the opinion of the members generally. Half a dozen other subjects of interest were embraced in the President's address. He would only mention the new Museum. That institution was parting from the Government; he regretted it, but supposed that it could not be avoided: they must not, however, part from the Architectural Museum. If the Government would not maintain it, the architects, the art-lovers, and the preservation of the nation must do so. There was now an opportunity to put up a suitable building, and they must endeavour to find the money for it, and he favoured the notion hinted at of bringing this Institute to take charge of.

All thanks to the President having been passed by acclamation, The President said he had received the greatest and highest reward that any author could do in feeling that what he had said had been acceptable to those whose good will and respect were so dear and precious to him. With regard to the question of the six selected names must be the stereotyped judges of the competition for the New Law Courts, as their appointment was part of a parliamentary arrangement. No judge, he believed, had yet been named for the competition for the National Gallery, but the names of the present First Commissioner of Works. He could assure them from what he knew of Lord John Manners, that the minister was fully alive to his responsibility, and that the most earnest and anxious care would be devoted to it. In the selection of judges it was not to be thought that at the same time Lord John Manners's hands would undoubtedly be strengthened by an expression of the feeling of this Institute such as had been suggested by Mr. Godwin—not worded as doubting his lordship's good will and good intentions, but as a delegation of a body of judges as would be satisfactory to the competitors and the public at large, and which would carry with it the earnest of a good building for the purposes to which it was to be devoted. The judges of the designs for the new Law Courts were nominated by Mr. Gladstone, Mr. Cowper, and Lord Cawsworth. The Law Courts were to be carried out by a special commission named in the Act of Parliament.

Mr. Dyson Wyatt suggested the propriety, upon the designs being sent in, of the lay judges so nominated procuring immediately a profession of architects, so that the standard should be raised. It was highly desirable that they should be put into possession of such information as an experienced architect could alone give them, not only before they should decide, but even, if possible, before they should commence their own examination of the drawings submitted.

Metallurgical Industry in Belgium.—The iron works in the district of Charleroi have for this year realised handsome profits, in spite of a slight augmentation in the price of labour, as well as in fuel. Great progress has been made in the manufacture of pig iron. Last year's production may be estimated at about 600,000 tons, of which scarcely 10,000 tons were exported, whilst on the other hand 26,000 tons were imported. Thus, the Belgian pig iron, which formerly served to supply the German and French iron works, is almost entirely used up in its own country. It is not now sufficient even for home consumption; and in general the trade has not been satisfied with the reduction of import duties, that are now only 5 francs per ton. All the Belgian pig iron is worked up in the country, and it only goes out in the state of malleable iron. This is of considerable advantage for the blast furnaces, which in this manner are no longer tributaries to foreign markets. This indicates at the same time the splendid possibilities which are opened up by the discovery of manganese in 1865, exported 57,000 tons less, and imported 120,000,000 more than in the preceding year. Free trade and the facilities of transport have given an impetus to the mineral districts of France. The situation of the mineral industry of the Charleroi district would leave nothing to be desired if the low price of coal were not an obstacle. But since the end of last year there has been a gradual rise, which begins to press heavily on manufacture. French markets for fuel are only obtainable with an augmentation of 20 to 25 per cent. on those of last year.
THE DESIGN AND ARRANGEMENT OF RAILWAY STATIONS, REPAIRING SHOPS, ENGINE SHEDS, &c.

By William Humber, Assoc. Inst. C.E.*

The rapid development of the railway systems in England and in other countries, has necessarily directed attention to the study of station arrangements; but the diversity of interests to be considered, the changes involved by a constantly increasing traffic, and the new and unexpected demands that have been made for accommodation, have prevented, in this instance, that general exchange of idea which has attended the progress of other branches of engineering. Hence the subject was not regularly brought before the engineering profession until a comparatively recent date; when, in 1858, a comprehensive Paper on railway stations was read at the Institution by Mr. R. Jacoby Hood, M. Inst. C.E.† So far as regarded terminal and intermediate stations, that paper touched upon most of the points of importance; but to one class—the arrangement of which is perhaps the most difficult of any that the engineer can be called upon to undertake—no reference was made. At New-street, Birmingham, there is a description of station neither entirely terminal nor entirely intermediate, but which may be termed "terminal-intermediate," as being a combination of both kinds. There is also another part of the subject requiring special notice, viz., that of goods and locomotive stations, which Mr. Hood was compelled to leave untouched. It will be the main object of this paper, therefore, to furnish information as to these heads, by submitting the details of the principal metropolitan and other railway stations, both terminal and "terminal-intermediate."

The classification adopted by Mr. Hood, viz., that of passenger stations; goods yards, wharves, and depots; locomotive and carriage sheds; manufacturers and workshops, will be adhered to. The arrangements will be illustrated by the goods yards of the London terminus of the Great Northern Railway, the Battersea workshops of the London, Chatham, and Dover Railway, and the carriage and wagon factory of Messrs. Brown, Marshall, and Co., at Birmingham.

The leading principles to be observed in general, are—proximity to the town, or most popular part of the neighbourhood which the stations are to serve; facility of access; and available space for present and future requirements. Each of these is capable of being further subdivided.

With regard to the first two requirements, it is desirable that terminal stations should be as near as possible to the great centres of traffic, without being actually in them; for in the latter case, the traffic of the thoroughfare and that of the railway would become intermixed, and thereby impeded. For stations generally, a site should be selected where the surface of the ground is near to the level of the platforms, and that this be not practicable, inclinations should be avoided, or excessively extended or embanked, in order to carry on the works on a level with the platform. All steps, gangway ladders, &c., should be dispensed with; the use of them is only justifiable where no other plan can be adopted. Beyond the station, however, a variation of the surface will be an advantage, by enabling level crossings in the streets and roads to be avoided. The possible contingency of having to extend the line, or to enlarge the station, should also be provided for, by a careful inspection of the surrounding and contiguous ground, and by laying out the first plans in such a manner as to admit of this enlargement, without involving the destruction of any permanent building, or the disarrangement of the existing accommodation. Upon the observance of these conditions will greatly depend the power of limiting the expenditure of money, and of abbreviating the time required to carry out improvements.

Terminal passenger stations are usually arranged under one of three systems—that in which the booking-offices are placed on the platform; that in which they are on the platform; and that in which the lines of rail diverge into a fork, having the offices between. Examples of these systems are to be seen at the Victoria Station, Pimlico, and at the Euston Terminus of the London and North Western. The Victoria Station may be regarded as illustrating the first two, the part of it occupied by the London, Chatham, and Dover Company having the booking-offices on the departure side, and that belonging to the London, Brighton, and South Coast having them at the end of it, and at right angles to the rails. There can be no doubt that the first plan affords, in the words of Mr. Hood, "facilities for giving the greatest length of setting down pavement," and is useful for a system of traffic in which the trains are frequent and depart at distant intervals. But though a large amount of platform accommodation is of importance, it is a question whether the length of the arrival platform should exceed that of the longest train. A departure platform, so proportioned, has the recommendation of readily admitting a second train behind the one already in the station; yet, in the absence of great attention, the attempt to book for two trains at the same time will lead to confusion. Sometimes the platform is arranged in steps, with a view to assign a distinct line of rails for each train, but by this plan some of the trains become inconveniently distant from the booking-offices, and the portion of the line between the head of the last train and the departure end of the shed is comparatively useless. Where the traffic is of a mixed character, involving the despatch of trains to different parts in quick succession, the second system is no doubt the best; and is, indeed, perfectly fitted for any traffic, if the shed be capable of containing the longest train which the traffic will require. This system also secures a great width of the shed allotted to the booking-offices being distinct, and opposite their several platforms. It is possible, however, that at terminal stations in large towns, a combination of the parallel and transverse systems might be employed with advantage. The third principal is illustrated by the Euston Terminus. The ample area of the great hall, with the booking-offices on each side, and the relative position of the trains, in the plan of placing the departure platforms on either side, and starting the trains from both, seems open to the objection of causing confusion. The London Bridge Station of the South Eastern Railway, before the extension of the line to Charing Cross, may be cited as an instance of how an immense traffic can be worked in which trains are very frequent, and a part of the accommodation, to a certain extent, of the three systems. Accommodation was thus provided for the South Eastern main line, and the North Kent, Mid Kent and Greenwich lines. Nowhere were so many trains despatched in the same time as from this station; and it is doubtful whether, except in an extensive and complicated traffic, such an extensive and complicated traffic could have been conducted. It is not, however, intended to adduce this station as a pattern of arrangement, for its history is that of a gradual adaptation to successive requirements.

The through, local, and excursion traffic should each be considered separately; for a passenger will be at the same time at once to see where he can obtain his ticket and find his train. Every facility should be afforded for receiving, labelling, and despatching luggage. Too much attention can hardly be paid to this detail and also to the situation of the toilet, luggage and cloak rooms. Those at the Paddington Station of the Great Western Railway are very convenient. Waiting and refreshment rooms should be of ample size, and readily accessible. It is well to separate the in and out parcels offices from the general traffic; and this can mostly be done by placing them at the end of the platform furthest from the passenger and carriage entrances, as at King's Cross and at Paddington. The lamp rooms should serve both for the arrival and the departure trains, as at the Great Western at Paddington, where their position is below the platforms and lines, the lamps being raised and lowered by hydraulic lifts.

In the urinals, &c., for passengers, slate has been generally used, but it does not appear to be so well adapted for cleanliness as the enamelled tiles or glazed tiles. Both closets and urinals should be arranged to perform the maximum of duty with the minimum waste of water. The small glazed basins require less than half the quantity of water needed in the slate arrangement, besides being always free from bad odour. At the Knottyngley Station, where the two plans are in use, the supply of water at the former is flush on opening and shutting the door, and the walls should be lined with a material not easily defaced. Lavatories for the use of first and second class passengers might, at both terminal and junction stations, advantageously be provided, and would, no doubt, be largely used, even if a small charge were made. The platforms for passengers should be spacious. For through traffic, at terminal and junction stations, the width should not be less than 30 feet. For local trains, docks may be taken out

* Read before the Institution of Civil Engineers.
of the extreme end of these platforms, as at King's Cross, leaving the wider part of the platform for the long trains. In order that the passengers may enter and leave the carriages easily and safely, it is essential that the platforms be level with the floors of the carriages, or certainly not below the upper step; many accidents have arisen, and the passengers in their ingress and egress are much impeded, by the neglect of this precaution. The stations of the Metropolitan Railway afford good examples of arrangement in this respect. Turn-tables should not be placed on the main line, or where engines or trains pass over them when not in use, as the ends of the rails and the rolling stock are injured by the constant hammering of the wheels. The use of traversers, especially when light and easily worked, cannot fail to save a great deal of labor and repair.

At terminal, terminal-intermediate, and large junction stations, where there is space available, the greater portion may be roofed in, as that part not required for the traffic will be found useful as standing room for empty carriages. If it be not possible or expedient to construct the roof in one span, the intermediate supports should be placed in the centre of a wide platform, in order to be free from the danger of collision, in the event of an engine or carriage getting off the rails. An accident of this description occurred a few years since, at the Bricklayers' Arms Station, where the roof was, in consequence, to a large extent destroyed. The height of a station roof is of far more importance than has been assigned to it; no contrivance can secure a proper amount of ventilation. The general impression, that a building roofed with iron and glass must be exceedingly hot during the summer months, has probably arisen chiefly from the insufficient height which is sometimes given to such structures. Gas, throughout all stations, is preferable to light, causing a great amount of inconvenience, which might have been avoided by placing the station upon the ends of the roads, or between them as it now stands. There are, however, two docks, one at each end of the platform, for those trains which commence and finish their journey at that station. The utility of this arrangement, as enabling passengers by local trains to alight on the platform for through traffic, and vice versa, has already been pointed out. It will prove a great accommodation also at these stations to have two through lines in the centre, and sorting sidings for the mineral and goods traffic. At all stations these two latter departments should, if possible, be distinct.

At large or intermediate stations, the best site for the booking-offices is of course on that side of the railway whence the greatest amount of traffic may be expected. If the station, however, be at a point where the line runs in a deep cutting, it is then judicious to place the offices over the line, which may be done by widening the road-bridge. The platforms are most conveniently arranged when the station is on a rising ground; the up line is opposite the upper end of that for the down line. No platform should be shorter than the longest train; nor should it terminate abruptly, but with a slope. At these stations the company will find it their interest to provide a residence for the clerk in charge; he will be near at hand in case of emergency, and his residence on the premises will afford greater security to property.

The next part of the subject to be considered is that of goods yards, wharves, and depots. A terminal goods station may either be attached to and form part of the passenger-station, though distinct from it; or it may be placed at a distance, and enclosed within its own fencing. It is important to take advantage of a water carriage, and to locate the station where the easiest access may be obtained. Ample space for vans and wagons should be provided in the yards and sheds, and also at the entrance gates and in the roadway, to prevent crowding, and to diminish the risk of accident. The platforms for arrival and for departure should be distinct, and of ample width, with an abundance of hydraulic crane power, to facilitate the loading, unloading, and sorting of goods; whilst the clerk's office should be so arranged as to allow of easy supervision. The lines and turn-tables should be so disposed, that the trains may be made up with facility and economy, and that the necessity for shunting with engines may be avoided as much as possible. In some small terminal stations, and at road-side stations, it is found convenient, and often essential, in working, to place the goods sheds close to the station, so as to enable the station-master to have ready access to this part of the traffic. In all cases the shed should be parallel to the line, that trains may be shunted into it, and the use of turn tables be avoided. The goods sheds, and the various buildings connected with them, should be arranged to lock up when not used; by this means the expense of a watchman is rendered unnecessary, and safety from pilfering is greatly increased. This plan is adopted with excellent results on the South Devon and Cornwall Railways. The other requirements of goods stations will receive more detailed notice in the description of the plans which have been adopted, as illustrated in the subject.

The development of the railway system has necessitated that all important lines should be provided with three classes of establishments—for manufacturing, for maintaining, and for storing the rolling stock, at one or more points. At the first, the locomotive and carriage shops, all the construction and repairs of the rolling stock are performed. At the second, small repairs, such as are required by daily wear and tear, are carried out; and the third, or engine and carriage sheds, are for receiving the rolling stock when not in use. Great care and forethought are required in the selection of suitable situations for these offices; for if any error is committed, a constant, increasing, and unprofitable charge is incurred. The most eligible locality for the locomotive and carriage shops is where labour and materials can be most cheaply and readily procured. Considerable study should also be bestowed upon their arrangement, so as to allow of the economic application of the power and the concentration of the material. It is generally a great evil to design them, as to necessitate unremunerative handling and shifting. The raw material should enter at one end of the shop, and pass on through its successive stages and processes, till it comes out complete at the other end. It is advisable, in all cases, for the District Superintendent of the locomotive and rolling stock to reside near the shed, and to have them constantly under his supervision. Carriage running and repairing shops, when as close to the terminal stations as possible, are in the best position for avoiding waste of time, wear and tear of stock. The disadvantage of placing them at a distance is exemplified by the Waterloo Station of the London and South Western Railway. The trains are made up at the terminus, where there is a small amount of standing-room, while the carriage sheds are at the Falcon Junction; in consequence of which nearly all the spare carriages have to be taken four miles, when emptied, and to be brought back again when required for service; and it is calculated that engines and empty carriages run in hundreds of thousands.

Engine and running sheds appear to be of three descriptions—rectangular, circular, and radial or fan-shaped. The circular shed is used by the Midland Railway Company, and the rectangular and radial by the Great Northern. The objections urged against the last are the length of line and the extent of ground occupied; but these objections are easily removed by placing the running shed in the centre, in front of the repairing shed, thus utilising what, without the running shed, would be a waste of space. Another objection is, that all the engines must pass over one pair of points; but this is not so serious as that of the single turn-table in the centre of the circular shed. In both cases, regard being had to the regularity of the traffic, the sidings should always be kept in covered sidings at the station. The accommodation afforded by the rectangular building in the centre of the fan is equal to that of the circular, though the area covered by the latter is nearly one-third more. There is no doubt, however, that the rectangular system requires a greater extent of permanent way; but this is partly compensated by
the less costly nature of the building. The semicircular shed, on the fan-shaped system, can easily be compared with the others; the only superiority it possesses over the circular is, that being a part of the station, it involves a great length of extra road from the turn-table when one is used, as at Battersea, and should that get out of order, all the engines must remain in the shed until the defect be remedied. An engine shed should be lofty, well ventilated and lighted, and sufficiently spacious to allow the men to pass round the engine without discomfort. The engine houses are properly paved, by the side of each line of rails in the shed, will afford free access to the machinery under the boiler when cleaning and repairs are needed. The best form for the bottom of the pits is convex; and the drainage should be from the sides, taking care so to construct the drains, that if any one pit should become choked, the working of the engine in any other would not be interrupted. For dropping and cleaning the fires, similar pits should be provided outside the shed, where the dirtier and rougher work can be performed. Plenty of water, with a good pressure, and accessible at suitable places by means of hydrants and stand-pipes, should be supplied, together with hose and conveniences for cleaning and washing the boilers. Lifting-shears, or overhead traversers, with powerful tackle, will be found of great service in every shed. By their aid an engine can be lifted and slung, so that the strain is distributed equally; they are therefore preferable to jacks, which concentrate the strain immediately over one point. The new shops at Nine Elms are at the top of a long flight of stairs, and the engine sheds at Mr. Joseph Beattie (M. Inst. C.E.), and the engine sheds at the Bishop's Road Station of the Metropolitan Railway, by Mr. Fowler (President Inst. C.E.), are supplied with traversers worked by steam power. These effect a great saving of space. The employment of duplicate traversers, working from each end, to prevent delay in the case of a break-down, will almost certainly be adopted. The coke furnace should serve for the largest number of engines with as little movement of the lighted fuel as possible. The waste heat can be utilised for drying the sand to be used in the locomotive boxes, and for heating the air. The water supply should be close to the lines leading into, or out of the sheds, so as to be accessible without shunting; and the stores in general should be adjacent to the repairing and running sheds, and planned with a view to prevent any material being taken in or out, without passing under the notice of the storekeeper.

The different kinds of stations belonging to the railway system of this country, their requirements, and some of the principles involved in their construction, having now been briefly described, it is proposed to refer in detail to the following existing stations, which are considered to embody most of the points touched upon—The Victoria Station, the London and South Western Railway, the Great Western Railway, the Great Northern Railway, the London, Chatham and Dover Railway, the Great Northern Railway at King's Cross, the London, Chatham and Dover Railway, the Great Northern Railway, the Great Western Railway, the Great Northern Railway, the Great Western Railway, the Great Northern Railway, and the Great Northern Railway at King's Cross.

At the Victoria Station of the London, Chatham, and Dover and the Great Western Railways, the booking-offices, &c. (at the entrance to which is a covered carriage-way), are on one side of the station. The waiting-rooms are conveniently placed near the booking offices, and the refreshment-rooms are large and comfortable, and provided for, the out-parcels, in-parcels, and left-luggage offices being very commodious. The lines running into the station are of mixed gauge; and three trains can be prepared to start at the same time. There are two departure platforms (one of which is worked double), and two arrival platforms, with a car-road between. On one of them is the Customs-office, for the Continental traffic. Connected with the station are sidings for passenger trains, a large engine-shed, a goods depot, and a turn-table. The cab-road has only one point of ingress and egress, an arrangement which is objectionable, from its tendency to cause confusion. The roof is in two spans, and the supporting columns are placed between two lines of rails.

At the West End Terminus of the London, Brighton, and South Coast Railway, the booking-offices and waiting-rooms are placed at the end of the station, and at right angles to the lines of road. There are separate offices, platforms, &c., for the Crystal Palace traffic, to prevent crowding. Between the arrival platform is a cab-road, having a distinct entrance and exit.

At the Euston Station, the booking-offices are placed on one side of the large entrance hall, from which access is gained to the two departure platforms. A glass roof shelters the entrance to the station. The New-street Station, Birmingham, is terminal—intermediate; intermediate for the London and North Western, and Midland Railways, and terminal for the Stour Valley line. It is in a cutting between two tunnels. The two main lines run through the centre of the station, and the platforms are approached by sidings, so that through trains are not stopped by the station traffic. The principal booking-offices are over the refreshment-rooms, and on a level with the bridge which is accessed to all the platforms. The way is indicated by broad arrows on the top of the bridge. The main platform is approached by several platforms, where fingerposts are placed to point out the destination of the several trains. An iron and glass roof, of considerable height, covers the station in one span.

The Stafford Station, recently erected, is terminal for the Great Northern Railway, and has a platform intermediate for the London and North Western Railway. Two main lines run through the centre, the platforms being approached by sidings. There are docks and sidings for the arrival, departure, and marshalling of trains for the London, Birmingham, Trent Valley, and Shropshire Union lines. At the North end are the painting-shop, engine-houses, and all the usual conveniences required at a terminal station. A short distance from the passenger station is the goods station and the sorting sidings. These it is believed, were first introduced by Mr. W. H. Barlow, M. Inst. C.E., on the Crewe Valley Railway, near Derby. When a mineral, or goods train arrives at Stafford, composed of trucks goods, the engine goes to the Shrewsbury goods station, or to the Shropshire Union lines, the trucks are detached and put into their respective sidings until a sufficient number is obtained to form a train. This arrangement saves time, and enables thirty-six goods trains to be dispatched from this station in the course of twelve hours. There are in all five sidings, two on the up-side of the goods station, one to accommodate the traffic; two for the coal-trade of the town; and there is one to the cattle waggons.

The Newton Junction Station is terminal—intermediate for the South Devon Railway, and a junction for the branch to Torquay and Dartmouth. It is very conveniently arranged. The approach is by a single line of track at one end; and there are three platforms—two for the main line traffic, and one for the Torquay and Dartmouth branch. Each platform is easily reached by means of a bridge over the rails. The principal offices are on the up-side; and there is a small waiting-room on the central, or Torquay platform. Near the station are the carriage repairing shops, engine-sheds, goods sheds, &c. Also the carriage repairing shops, are supplied with a traverser, by which the carriages are deposited on a short rail connected with a large turn-table at the end, and are then turned on to any line, when required for use.

The goods station of the Great Northern Railway at King's Cross, has goods sheds, warehouses, &c., for the goods required at this station. The goods shed is divided into several sections, and has a new goods yard, with a line to it. There are four goods goods sheds, roofed over, and several large goods goods sheds, with large sidings and sidings provided for it.
and distributing the goods. The outer line of rails on the east side of the platform is used for unloading the trucks with the inward goods; and that on the west side for loading the outward goods. The inner lines nearest to these are used for the arrival goods trains, for empty trucks, and for making up trains for departure. The trucks, after being unloaded, are taken, by means of tugs and cranes, to the detached side of the station, where the business of loading and deepshifting them is carried on. The platforms are commodious, and each have two rows of hydraulic cranes, of alternately one and two tons. The receiving-offices are on the platforms, but the general offices are adjacent to the main building. The stables are under the platform, and the armorial bearings and fighting lights are therein. The grany is at the south end of the goods shed, through which it is approached by two lines running through the centre; two other lines, one on each side of these, being reserved for full trucks. When emptied, the trucks are removed by two lines, which run one on each outer side of the goods shed. The latter and the grany are supplied with water-communication through tunnels under the roads, to a basin on the south; and thence by the same means with the Regent’s Canal, so that lighters can receive or discharge their freights directly under these buildings. On the west side of the goods shed are two coal depots and stables; and a coal and a stone dock, also connected with the Regent’s Canal. Adjoining are numerous private wharves for bricks, &c. On the north are the engine, repairing, and carriage-sheds. There are eleven lines in the centre, at the extremity of the fan, in the repairing shed, with shops in the rear; seven lines on the south, in the repairing shed at the front; four lines, in the carriage-sheds. The running shed is placed in the centre of the fan, in front of the repairing shed, with which it communicates by through lines connected by means of a traverser. The potato-store and market occupy the eastern portion of the station, and are near the Midland goods shed. The whole is conveniently arranged, and all well cleaned and well kept up.

The locomotive workshops of the London, Chatham, and Dover Railway are situated near the Stewart’s Lane station, on the Metropolitan extension of that line. The works proper are encased by a wall. At the entrance from the railway, there is a building on the right, for the timekeeper and police. A single line connects this with the main line, by means of points and crossings. Two parallel lines, running east and west, are connected with the several buildings by turn-tables. On the north of these lines is a range of buildings, containing the engineer’s offices, boiler-house, coal-store, grinding-shop, and turning-shop. On the south, under one roof, are the boiler-maker’s shop and the machine-shop. These are composed of twenty stalls on each side for engines, and a traverser which runs north and south. On the west of this building is a hooping and tying shop, with a traverser connecting twenty lines near the north end of the carriage and wagon shop. Further west are the saw-mills; and near these at the extreme west, the engine for running these shops, and the engine’s and foreman’s offices. A line of rails connects the above shed with the works, through an engine weigh-house.

On the left are two smiths’ shops, parallel with the public road beyond. These are intended for the supply of iron-work only; this arrangement has proved advantageous, by obviating the necessity of interfering with the progress of the carriage work. To the right of the smiths’ shops are the bolt shops and the fitter shops; in the former all bolts are forged and screwed, and in the latter all the wood-work is planed, tenoned, and mortised, before passing into the carriage and wagon shops. In each of the latter are eight lines of rails and a traverser communicating with the sidings. The carriage painting shop is placed next the erecting shop, and communicates with it, but is sufficiently removed from the painting shop for the light, heat, and fumes of the latter to be effectually prevented. It has four lines of rails, communicating with the traverser just mentioned; and has attached to it the paint stores and trimming room. The carriage-body shop and wagon repairing shops, are provided with a traverser through the centre, and communicating with the sidings. The general stores stand in front of the wagon shop. A building in the yard is the shipping stores, where the packing and marking are completed. The packages and cases are run upon a tramway, to a crane placed by the inner siding.

The foregoing have reference only to systems and establishments now understood but successfully working. It should be understood, that it is impossible to lay down rules which shall be applicable to all railway stations. The formation of the ground, the nature and extent of traffic, the capital to be expended, and the views entertained by the directors and the traffic manager, will inevitably modify the arrangements in each case. In the present, as in former rules, the latter is only of the nature of a guide, and the others are only exceptional; but even in those which are more on less indispensable, no absolute rule can be given. Much therefore, must always be left to the skill and adaptive power of the engineer. Yet the Author would remark, in conclusion, that if, in addition to the essential qualities of a station—spaciousness, cleanliness, and well-chosen form—others are frequent, the fares moderate, and even low, and if attention be paid to the comfort of the passengers, the results can scarcely fail to be satisfactory.

DEPOSITION OF METALS.

The following is the account given by Dr. Dullo, in the Journal d’Industrie, of the method adopted in Germany for covering cast-iron objects with copper. The surfaces are cleaned with a brush and hydrochloric acid, and the objects are then left in water slightly acidified; they are afterwards placed in a bath consisting of 10 grammes of chloride of iron and 14 litre of alcohol, in contact with metallic zinc, the surface is covered with a fine silvery deposit, which adheres firmly to the copper. Copper may be also deposited with a layer of antimony by the following process:—Dissolve chloride of antimony in alcohol, and add hydrochloric acid until the mixture becomes clear, clean the inner well, and leave the bath with the use of the crucible. The effect of the alcohol in the preceding processes is thus explained; it moderates the precipitation of one metal from its solution by another metal, and causes the precipitate to fall in an extremely divided state; when alcohol is used alone, without water, the coating of copper thrown down is reduced to a massless powder, and is useless, and is required; when the work is finished it should be well washed, first in water, and afterwards several times successively with a solution of carbonate of soda, and with weak hydrochloric acid, and finally carefully dried in a warm place. The perfect silvery of vases, or plates of glass, is always a matter of some difficulty, and the last process is indispensable. The method is as follows:—Four solutions—first, 10 grammes of nitrates of silver to 100 grammes of water; second, an aqueous solution of ammonia, of
THE CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

[December 1, 1866]

O-984 density; third, 20 grammes of caustic soda and 650 grammes of water; and fourth, a solution of 29 grammes of sugar in 200 grammes of water, to which is added a cubic centimetre of nitric acid, at 38°; and let the whole boil for twenty minutes. When cold add 60 cubic centimetres of alcohol, and as much water as will make up the total quantity to 600 cubic centimetres; then take 12 parts of the first, 6 parts of the second, and 20 parts of the third solution, add 60 parts of water, and let the mixture stand for twenty-four hours; lastly, the solution No. 4 is added, when the whole becomes of a blackish tint, in consequence of the finely divided precipitate of silver which begins to fall. M. Reichardt has discovered that the deposition of the complex compound is well accelerated by being continually shaken, and that by this means the deposit on the inner surface of glass vases is always satisfactory, and he recommends that in silvering plates of glass they shall be placed in evaporating dishes, or other vessels, so that the sides may give an oscillating motion to the liquor in the bath when shaken. In acting on large articles he recommends the glass plates, or other objects, to be fixed within tubs or vats, which may then be rolled or rotated pretty rapidly.

THE INSTITUTE OF CIVIL ENGINEERS.

November 13th—The first Paper read was on the "Results of the Employment of Steam Power in Towing Vessels on the Gloucester and Berkeley Canal," by W. B. C. CLAROM, M. Inst. C.E.

It was stated that this navigation was 181 miles in length, and level from 10ft. to 25ft. at the highest point and 5ft. at the lowest; the width of the canal varied from 80ft. to 100 feet, with passing places from 150ft. to 200 feet wide, and at the bottom from 13ft. to 20 ft., while the depth of water was from 16ft. to 18ft. 6in. See-going vessels up to 700 tons register, and drawing 14ft. 6in. would reach Gloucester. Prior to the year 1860, when the vessels were towed by horses, at a cost of about one farthing per ton per mile, and at speeds varying from 1 mile to 3 miles an hour. At the date named, three steam tugs, fitted with high-pressure engines and screw propellers, were operating on the canal, and the cost of these vessels was 1,000,000£. The register of shipping had been 16 tons, carrying 1,109,334 tons of goods, at a cost of £6,400, including 15 per cent. on the price of the tugs, to overer interest of money, repairs, and renewals. Applying this outlay to the tonnage of the vessels towed, it gave £6 penny per ton for 16 miles, or £0-66 (about one-twelfth) of a penny per ton per mile,—being a saving of not far short of two-thirds, as compared with the horsepower.

In consequence of a larger and more regular trade in the six months ending June 15th, 1860, the number of passengers that year was 16,000,000, the charge for carrying each person was one penny per ton per mile, the cost of transportation was 40% per cent. on the price of the tugs, and 8-96 per cent. of the cost of the vessels. The revenue from the tolls to the trust amounting to £16,000,000, in hailing the cargo traffic upon the summit level of the Regent's Canal,—where the sectional area of the waterway traversed as compared with that of the vessels navigating the canal was about 4 to 1, and the vessel has the advantage, on account of these proportions, of running at 1-2 miles an hour. The distance traversed was 3,019 miles, the number of barges hauled 90,000, and the amount of external revenue 30,000£.

The employment of steam as a towing power had been found in nearly every way advantageous. The work was greatly economical. The vessels rubbed much against the sides of the banks, the towing power being right ahead, and not on one side, as with horses. The wear to the ropes used in tracking was reduced; and vessels could be moved along the canal in weather which would have prevented horses doing the work. The speed also was increased; and owing to this, there was now no difficulty in following the canal, as the towing tug formed a part of the boat. It was considered to be that by which small direct acting engines were fitted in a barge, capable of taking 40 tons of cargo, and of towing one, two, or three canal boats after her, according to the strength of the stream against which the tug was working. The larger and stronger vessels, partly river and partly canal, the employment of steam power had been so profitable, that all sailing vessels and hauling by horses were being rapidly abandoned, when dependence would be placed upon steam barges alone. A series of experiments had been made on the Ashby-de-la-Zouche canal, for the purpose of determining whether the application of steam power would be injurious to the canal, particularly to the banks, when it was found that no prejudicial action took place, so long as the speed was limited to 3 miles or 5 miles an hour.

Russian-American Telegraph.—Nearly the whole of the surveys on land and the soundings in Behring's Straits are completed. The following works will be completed this year, distributed amongst several sections. The line of telegraph will be lengthened 800 miles beyond the Port of Granley to Kvitthok, and further in the valley of the Anadyr from its mouth to the Island of Anadyr, from Okhotsk to Kuyalmik, and, perhaps, to the junction with the Anadyr section.
THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Certain alterations having become necessary in the management of the affairs of the Institute of British Architects, it has led to the reclassification of its office-bearers, and particularly to the appointment of a paid assistant-secretary. For this post we understand that the applications are numerous, including the names of several good men and true, the consideration of whose claims will be brought under notice at the meeting on the 3rd inst., and that a decision whatever to the merits of other candidates, the list, so far as published, contains the names of at least two gentlemen who have special claims on the attention of the Institute, in consequence of their long connection with the Institution and the practical services they have individually rendered in furtherance of its interests. The name of Papworth (one of the candidates to whom we refer) in conjunction with his brother, to improve and render more available generally, the accumulated treasures in the library, has been neither few nor unimportant. Mr. T. Dollman, the other gentleman to whom we allude, though in official connection with the Institute, is more recently than some of his brother officers, has, we believe, by the unanimous testimony of those best qualified to give an opinion, discharged in a very zealous and efficient manner the duties of librarian, by which he was elected some four years ago; being moreover an individual well and favorably known as an author more especially by the light of his manuscripts, and his detailed and illustrated works, bearing upon medieval architecture. Mr. Dollman may therefore naturally consider that the services he has rendered in both capacities present more than an ordinary claim to notice, and that his experience in the post just vacated will add not a little to other recommendations.

Among the candidates are Messrs. Edward Hall and C. L. Eastlake, both known in literary circles, and Mr. F. Warren, Mr. Snell, and Mr. Wallace.

THE PROGRESS OF ENGINEERING.

The Institution of Engineers in Scotland commenced the Session 1866-7 on the 31st October last, under the Presidency of Mr. J. G. Lawrie, who delivered an introductory address, embodying an interesting sketch of the progress of scientific engineering. The proceedings of this Institution are of much interest and utility; some extracts from the President's address we append:

Great were the advantages derived from the original form of the steam-engine, in which the same vessel performed the duties of steam cylinder and condenser, it is nevertheless an instrument immensely behind the modern engine. The invention of a mechanical prime mover, which should be independent of the action of the wind, and which, not being attuned to situations where falls of water existed, could be placed anywhere and extended indefinitely, possessed, plain advantages wholly unattainable without such a prime mover, and was therefore fitted to produce an entire revolution in operations dependent on the exertions of dynamic force. Beyond the applications falling within the scope of a prime mover, such as the original form of steam engine, there existed even a wider range to which such a prime mover could not be profitably applied, and which, consequently, were as entirely shut out from that class of prime movers as if it had not existed. For these, the more perfect instrument in the modern steam-engine is peculiarly adapted. In steam navigation, for example, the improved steam-engine is rapidly becoming indispensable. For that purpose the difference between an engine which uses 4½ lbs. of coal per horse power per hour, and one which performs the same work with 2½ lbs., is so great in many cases while the one is very much what the circumstances and conditions require, the other often a waste of fuel. The former would alone in many cases be a bar to its use; but when to the expense of the fuel is added the incompatibility of burning 4½ lbs. of coal per horse power, with the requirements for carrying cargo, the application of such a prime mover is wholly out of the question, and brings into prominent contrast the advantages of the latter. And these advantages are most prominently services rendered by science to the engineer. The advantages obtained by expanding the steam, the advantages of surface condensation, and the advantages of modern superheating, which constitute the improvements of the modern steam-engine, are due altogether to the scientific engineer. No one who has been the subject of a different mode of care has been due to elaborate and patient investigation. It is true that the amount of advantage derived from any one or all of these improvements has not yet been by common assent definitely ascertained, the experience of different engineers showing different results, arising, probably, to a large extent from inaccuracy of observation, and due also, to the different modes by which the advantages are sought to be arrived at. While, however, these different results are being discussed, questioned, and not unfrequently discredited among the doctors, the users of the steam-engine, the public, are plainly in practice answering all doubts by a steadily increasing demand for the improved steam-engines, showing that, although different forms may yield different amounts of advantage, they all, in every practicable form, yield results of sufficient advantage to induce their extended application. The progress made by these improvements points palpably to the time, and at no distant within, probably, fifteen to twenty years, when in steam navigation, for every work, except it may be the shortest of running voyages, the injection condensing steam-engine will be entirely obsolete. On a vast variety of stations the question is not one with a consumption of 4½ lbs. of coal per horse-power of more or less profit, but it is whether there is to be or there is not to be steam navigation. Steam navigation compared with sail navigation are so tangible and so great as to ensure the unmentioning attentions of engineers to the entire removal of the remaining difficulties in the way of the improved steam-engine. The great ocean race from China, which has received so much notice within the last few weeks, undoubtedly, is a very few years, lose its prominence, and be eclipsed by a race of far higher speed.

The great and prominent improvement in the steam-engine, as applied more particularly to steam navigation, is the economy of fuel, and without that improvement all the others that have been made would have been worthless, but with that improvement other great values have been added to the advantages of the paddle wheel to the screw propeller. For many services, the paddle wheel was a most clumsy, inconvenient, and undesirable mode of propulsion. For all services, except, as yet, in shallow water, the screw propeller is nearly all that can be desired.

Recently, a method of propelling ships by the reaction of water issuing from a turbine water, now copiously developed, the Rutlven mode of propulsion, has been revived, and has lately been tried in one of her Majesty's ships, the "Waterwitch." This method of propelling ships is not without advantages peculiarly its own. For example, in many ships, and perhaps in all, the great power which a ship so fitted possesses to endure an immense amount of water without injury, it may be, of leak or injury, is of no inconsiderable importance. Probably, a facility of maneuvring a ship so fitted is another advantage. But there are no good grounds for believing that this mode of propulsion will be more economical in the application of dynamic effect or power, or in fuel, than the screw propeller, nor even that it will be so economical.

In a comparison of the two modes of propulsion, there are three elements which fall to be considered:

1st, The consumption of the power of the machinery due to the friction of the propelling instrument.

2nd, The consumption of the power of the machinery due to the loss of it which is carried off by the water projected from the ship.

3rd, The consumption of the power of the machinery due to the propulsion of the ship, or that is developed in the propulsion of the ship.

To compare minutely the friction in the two methods, it would be necessary to know the surface, in each case, of the propelling instrument; in the one case the surfaces of the screw propeller, and in the other the surfaces of the turbine wheel and the surface of the water passages. Even, however, without these measurements, it is plain that the screw propeller has the advantage to the large extent in this regard of the propelling instrument itself is manifestly in favour of the screw propeller; and the loss arising from the friction of the water in the water passages with the turbine wheel has no counterpart at all with the screw propeller.
With regard to the consumption of the power of the machinery in that part of it which is carried off by the water that is projected from the ship, it is to be observed that with the screw propeller, if there be a sufficient number of blades, the whole water in the cylinder, of which the diameter is the diameter of the propeller, and the length the length of the ship, is driven off with a certain speed which makes the reactionary power obtained in that way for the propulsion of the ship. If this cylinder be reduced in diameter the water must be driven off with a higher velocity to maintain undiminished the reactionary power derived from that source; and, instead of the greater carried off, the greater carried off being developed in the propulsion of the ship, increases as the square of the velocity, plainly the higher the velocity with which the water is projected from the ship the greater the power carried of to waste. Consequently, in this respect the turbine wheel plan adopted in the "Waterwitch," in which the discharge orifices are of small dimensions, comparatively, and, therefore, the velocity with which the water is projected necessarily considerable, is inferior to the screw propeller.

With respect to the consumption of the power of the machinery due to the propulsion of the ship, it is to be observed that with the screw propeller the power of propulsion is derived from two different sources. One being the power with which the water is projected backwards from the ship, and the other due to the reaction of the water in having imparted to it the velocity with which it is projected from the ship. For example, suppose the ship be propelled through the water by a propeller working in a solid, as it could be by having for illustration a propeller shaft of iron, all the power of the machinery, with the exception of that required for friction, would be employed in propelling the ship, and none would be carried off by water being projected backwards from the ship, because none would be so projected. When, however, the propeller works not in a solid but in water, there is plainly reaction obtained for the propeller shaft; and all the reaction is taken advantage of, and the water in having velocity imparted to it, and then there is reaction corresponding to that velocity. The reaction due to the inertia of the water in having velocity imparted to it is measured by the rapidity with which that velocity is imparted, and is represented by a quantity proportioned directly to the velocity, and inversely to the time in which the velocity is imparted, or in other words, is represented by the expression the velocity divided by the time; and if, therefore, the time during which the velocity is imparted is reduced to one-half, or one-fourth, or one-tenth, or is infinitely reduced, then the reaction obtained from this source is increased twice, or four times, or ten times, or is infinitely increased—that is, if the time during which the water is taken from the water to with great rapidity, the reaction will be equal to that of the propeller working in a solid. With the turbine wheel the reaction obtained from the inertia of the water in having velocity imparted to it is plainly much inferior to that obtained with the screw propeller.

In all the three elements the screw propeller appears therefore to have the superiority.

1st. In the friction of the rubbing surfaces.
2nd. In the quantity of power carried off to waste by the water projected backwards from the ship.
3rd. In the quantity of power which is developed in the propulsion of the ship.

And the extent of superiority depends upon the details of the manner in which the two methods of propulsion are carried out. The "Waterwitch" has already been submitted to a trial on the Thames, and in the report on the subject which has appeared in the Times it has been greatly praised. The method of propulsion has been lauded, and the machinery by which the method has been carried into effect has been also very considerably trumpeted. The facts, however, stated in the report do not afford the means of correct inferences respecting the result obtained, and the further experiments yet to be made are probably destined in actual practice the true character of this method of propulsion.

Illustrations of the progress of scientific engineering could be multiplied to almost any extent. Within the last few years engineering has been rapidly changing character. Formerly engineering was not nearly so much as now a succession of scientific improvements. Then it was enough in a sense to be a house of wood and drawer of water, and to travel in a beaten path; but now it is far otherwise, engineering being in all directions full of novelties—the dictates of science. The mode of communication between distant places is, we have seen, entirely new, and is the result of laborious, patient, and keen investigation of the occult laws of nature. The mode of conveyance both by land and sea is full of the same phenomena. 

THE ARCHITECTURAL ASSOCIATION.

The regular fortnightly meeting of this Association was held on the 23rd ult., Mr. R. W. Edis, the President, in the chair. The Secretary stated that the register for architects' assistants kept in connection with the Association, had hitherto been kept open for the insertion of all comers.

This was considered scarcely fair, inasmuch as the Association, and it was therefore proposed to alter the rule, so that while members continued to have their names placed on the register free of charge, non-members would not be admitted to it.

It was therefore proposed to charge a fee of 1s. for registration, and 2s. 6d. to members of the profession who were suited with assistants. It was therefore proposed that the words "to be consulted free of charge" be left out of the charge, and that the cost of the register be all charges fixed.

The annual report of the Committee of the Association, for the session, 1864-65, which showed that during the session 78 members had been enrolled, and in the same period 23 resigned, making a total addition of 55 to the number of members. A summary of the papers read and of the business brought forward on each evening of last session was then given, and a unanimous vote of thanks was accorded to the officers for the attention paid to their duties.

The annual report stated that — "The library has increased in books and in the number of readers. A sub-committee was appointed by the Association, to consider the whole question and on their report, it was decided that the present subscription be abolished, and the library thrown open to all the members, and that a voluntary subscription of small sums be instituted towards increasing the number of books. A sum of £2 5s. 6d. from the funds of the Association was voted, and a subscription list is to be opened. The hope that the members generally will make use of this important branch of the Association. The class of design continues to thrive, and the sketches and drawings contributed speak well for the ability of the members, but although a great number of sketches were sent in, there were but four
gentlemen who were eligible for competition for the prizes; as having contributed the requisite number of designs during the session.

The work of this committee continued, because the subscription list for the examination class had ceased to exist, especially as the sole cause was the scanty attendance of members, and which repeated efforts have been unable to overcome. Whether the present unsettled state of the architectural examination class will continue, and whether a class with members paying tuition fees for the examination class was considered useless, it is impossible to say. The committee urges the members, the younger ones in particular, the extreme importance of this class and the benefit to be derived from it, and they still hope that the principle of free tuition will be continued. The principle of giving free tuition in this class would be more acceptable, whether the name of a voluntary examination class or otherwise it did not matter. It did not oblige the President, as a member of the Institute, to say anything against that body, but he confessed he thought it a very bad plan to have them pay tuition fees for the voluntary examination scheme in the manner they had done. The Institute had asked for suggestions for improving the examination scheme, and when a large number of valuable suggestions had been sent in they had acted on them all, he said. The evil was all pointed out, and the examination was tantamount to a myth. He hoped that the question of architectural education would be long put on a more satisfactory basis, and that ultimately there would be a compulsory, not a voluntary, examination of all professional students. The members of the committee would require to continue their efforts in memorializing the powers above, and if it was found that the Institute would do nothing in the way of granting a diploma or some other recognition, then it would be time for the Architectural Association to do something for themselves. The President next remarked that it was a matter of regret that out of nearly 350 members of the Association only twenty-two belonged to the figure drawing class. This was a most important study, and deserved a great deal more attention from students than was given it. He believed the members of the committee regret that almost the whole were thrown out by the general body; so that few alterations from the former scheme will be made. While deplores this, he would still say, "Go forward," as upon the spirit in which the examinations are taken up by the younger members must depend success. The committee urges on the members to present themselves as well for their own sake, as for the profession at large.

The class for the study of figure drawing which was established in the last session, and the results which its members have brought as to the improvement of the members attending, has been satisfactory. This class differs from the others, inasmuch as it admits non-members of the Association, but the committee hope that some arrangement may be made whereby the former may be reduced. A class for the study of water colour painting and sketching was organized under the direction of Mr. A. Penley. The class was necessarily limited in number, but the success has been very encouraging to all its members. The committee reminded the members of the rule that gives them the opportunity of forming classes in the study of various subjects. A good example having been set by the water colour class.

Upon one subject the committee express their disappointment. With a view to stimulating the members to exertions, prizes were offered by the Associate Architects, Mr. W. Combe, Mr. W. Titre, and Mr. Goodwin, for competitions for essays and designs, but considering the large numbers of members, the offers have not been responded to in the proportion that might have been expected. In the past, the Treasurer announced the Association entirely out of debt, and with a substantial balance in hand; which would be materially increased if the members would pay their subscriptions as they fell due, by which means a great amount of trouble and expense would be saved, and the members would be able to give, instead of four, the exact amount that funds had to enable them to extend the usefulness of the Association. During the past session the committee met three times, and from the vote that was passed at the last meeting, believe they have gained the confidence of their fellows, aid would beg the library of expressing their thanks to the President, Mr. Robert W. Edis, for the exceptional attention and interest he has shown in all that concerns the Association, and they have pleasure in seeing the rules as altered as to render him more peculiar a member, than by becoming useful members of the Architectural Association.

The report concluded by stating that, "In looking back on the former years of the Association, it is almost wonderful to notice the rapid progress that it has made, but while taking pleasure in this, it should be remembered that the years to be devoted to it have been but a small part of the forty years in which the members have been in being. Members have been in and out of numbers and want, and with it our own profession, therefore it behoves every man (and especially the younger ones), for their own benefit as well as for their own profession, to qualify themselves for their future work, and in few cases can this be more pleasantly and readily accomplished, than by becoming useful members of the Architectural Association."

The President, in moving the adoption of the report, said he must first express the regret that the annual meeting to be held, however, of the proceedings of the class was not more successful as to the examination report which they had prepared. On the subject of the library, he considered that the change which has lately been effected in making the library free, and the subscription a voluntary one, was most beneficial. It was an effort to make the library a popular one to all classes of members, and the result is that the library has been entered upon a third session. Much praise and many thanks are due to Mr. Poynor, for the ready and explanatory manner of his teaching, and the committee has great cause to regret his resignation. The committee wish to express their thanks to Mr. Macdona for the services of the West London School of Art, who has always rendered them every assistance in his power. The number of members who joined the class between October and May was 50. Amongst these were a few artists and decorators, but the bulk of the members belong to the Architectural Association."
Mr. L. W. Rixton inquired whether the Institute had taken any steps towards the formation of a School of Art in connexion with architecture, as suggested by Mr. Geo. Gilbert Scott. The President said he believed that the Institute had not taken any action in the matter.

Mr. J. D. Mathews, the Treasurer, read the balance sheet for the past session which showed the total receipts from all sources to be £176 0s. 2d. and the expenditure £160 1s. 10d., leaving a balance in hand of £15 1s. 4d. He said it was a matter of privilege to say that the Association was out of debt. The committee had made a grant of £5 to the library, and had voted 25s. per month to the figure-drawing class.

The President, in proposing the adoption of the balance-sheet, proposed a vote of thanks to the Secretary (Mr. J. D. Mathews), for the able and earnest manner in which he transacted the business of the Association.

The balance-sheet was adopted, and the vote of thanks to Mr. Mathews was unanimously carried.

The President read the report of the delegates to the Architectural Alliance Meeting on 3rd July, 1866, as follows:

"Two only of your delegates to the Alliance. Messrs. Thos. W. Rickman and Robert W. Edis, attended on the 3rd July last at its meeting in Conduit-street, and the meeting was occupied throughout the day, first in the consideration of the various resolutions of the allied societies relating to the propriety of making the bills of quantities part of the contract, and also with regard to which question, although it was generally admitted that it was one of much importance, and deserving of the attention of the profession at large, it was not considered at present desirable for the Alliance to take any action thereon, involving—as any change in so important a matter must needs do—a very considerable amount of alteration in the present bills of quantities for hats and caps. At length, everyone was unanimously of opinion that there was a question which, in my view, could not possibly be adjourned to the next meeting without the danger of the subject being altogether deferred, and receiving great attention, and one which was deserving of the serious discussion and consideration of the architectural societies throughout the country.

The question of the form of contract was turned over to the consideration of the form of contract proposed by the Birmingham Society. The position of the architect as regards the builder and his client, is one of so much complexity that it was felt that no conclusion could be at present arrived at which would be satisfactory to or essentially concern the builder than at present, and which might also take away from the architect all responsibility as regards questions of dispute between his client and the builder after his certificate of completion had been given; and it was considered by several of the delegates that there were so many reasons for making the bills of quantities form a part of the contract, inasmuch that any error therein on the part of the surveyor would necessarily cause unpleasantness between the architect and his client, and, in reality, much power would be taken out of the architect's hands by such an arrangement. It is only fair to add that in view of each of these proposed alterations, those who had actually tried them were in their favour. But in both these questions, your delegates have considered as eminently worthy of consideration and discussion by the several societies."

The President observed that on the question of whether bills of quantities should form part of the contract, the Association delegates (Messrs. Rickman and Edis) held different opinions. At the meeting opinion was about equally divided, and the question was left in an unsettled state.

The reports above quoted were in each case adopted.

RUSSIAN RAILWAY CARRIAGES.

Russian railway carriages are thus described by the correspondent of the Times:—"The distances travellers have to perform in this country are so immense, and the weather is so frequently so severe, that the idea of giving a sort of domestic arrangement to the cars naturally occurred to a people labouring under such disadvantages. Russian railway carriages are little houses on wheels. In the first, and partly also in the second class, their interior may be described as a salon, with all the necessaries, and some of the elegances, of such an apartment. It is furnished with looking-glasses, heated by porcelain stoves, and lit by lamplight and candles. Along the sides soft divans are ranged, and disposed around small tables. At the window, windows with red curtains exclude not only the rude touch of the Russian air, but also the aspect of the wilderast sky. The company sits or lounges about, chatting, reading, or playing chess, cards, or dominoes. The day passes pleasantly enough, and as night comes the passengers betake themselves to rest almost as comfortably as at home. By a simple process the divans are made into beds, and supplied with pillows by the attentive guard. In the first class the carriages are also provided with second stories, so to say, reached by an elegant stair-case, and fitted with complete beds; in the second, if there be too many passengers to be accommodated on the divans, part of them are lodged in berths, which take the place of the rack-propped laces round the window cases. Without, the very picture of cleanliness—they are well-stocked receptacles of the good things of this world within. The passengers enters a large vaulted hall, scrupulously whitewashed, and paved with flags. On long tables a sumptuous repast awaits him, every plate over a lighted lamp to maintain the warmth equally necessary in this country for taste and wholesomeness. The wines and beers of every clime are represented in numerous bottles, alternating on the neatly covered tables with steaming plates. The hall is in the bare, cold style so often met with in this country when pomp is not intended; but the viands are good, the waiters ready, and their white gloves unexceptionable. Indeed, the food is excellent. Such luxuries as these are still regarded and paid for as exotic in this distant latitude. The station is an oasis. Round about, the aboriginal race of the country lives in wooden cottages, including the whole family and their quadrupeds too, in a single room."

THE ROYAL ACADEMY.

The new regulations, long under deliberation, having received the needful sanction of her Majesty, are printed and circulated, and will forthwith come into operation. They relate primarily to the number, nomination, election, and power of associates. The concession is made that the limit of 500 Associates may not be exceeded; the minimum is fixed at that number, but the maximum is left undefined. Under this law, it will be possible to widen the area of the Academy, so as to make it commensurate with the art talent of the country. As to nomination of Associates a change has been effected. The old ordinance, which required a candidate to inscribe his name in a book, was regarded as needlessly and humiliating. This condition to election is now abolished, and in its stead a candidate will be proposed and seconded in writing by some friend in the Academy. The elections will be then made from the printed lists of all the candidates, and the votes and names of the voters may be known on demand of the majority. Associates are now, for the first time, entitled to vote and thus vested with power. The election of associates will take place in January, and of Academicians in June and December, of each year. Though the number of Associates may be indefinitely multiplied, the prospective right to a pension can never be vested in more than twenty at a time. This safeguard will remain for long superfluous. Other reforms already resolved upon await the accession of space which the new building will afford.

Coast Semaphore and Telegraph.—The semaphores erected on the coasts of France have just been placed at the service of the commercial world. These semaphores being in relation with those of the coasts of all the great powers of the empire, captains of ships may now make known their wants, send orders, or receive instructions and news without the necessity of entering ports or harbours, or even of quitting their course for shallow waters. Elaborate instructions have been drawn up by the Ministers of the interior and of the marine, and sent to all the ports and chambers of commerce in France and abroad. By means of the semaphore and telegraph, the speed of communication has been increased on all these coasts, and the cost of conveying messages is much reduced. The code of commercial signals is now well known in all the countries of the European continent, and has been adopted by all the nations that have a commercial intercourse with other nations. The English Government is now establishing semaphores along our own coasts on the same plan, and in connection with the same system of signals.