

kept pace with by the opening of new means of transit, by the association of capital in large companies, and by the constant improvement of the methods and apparatus of working. As far as I have had the opportunity of forming an opinion, the working colliers are generally inferior to our own in working energy, but superior in steadiness; and a great part of the credit for the present active and intelligent conduct of the French coal trade is due to the excellent technical training received by the superior officers and managers at the schools at Paris, and so usefully afforded, in a different degree to the class from which the sub-officers are taken, by the local mining schools of St. Etienne and Alais.

The Prussian authorities have exhibited several instructive models, representing their methods of excavating the seams of more moderate thickness in the Sarrebrück coal-field—pillar workings as well as a variety of long-wall, some following the level course, others the rise of the strata. Another representation of particular interest shows the removal, in one working at the Königt Grube, Upper Silesia, of the Sattel-Rötz, a seam about 24 ft. thick. The borders or stalls are driven 15 ft. wide, with pillars of 20 ft. between them; and the getting of the upper part of the seam is aided by the use of door-frame sets of timber of great height, which would entail heavy expense, unless a large portion of them can be recovered.

By no means the least interesting part of the Exhibition, in connexion with the daily life of the French colliers, is the indication offered by some of the largest colliery companies of the efforts made to improve the moral and material condition of their workpeople. Anzin, near Valenciennes, exhibits models and a series of plans of colliers' houses built by the company; and Blanzy (Saône-et-Loire) has erected in the grounds a full-sized house, of a pattern largely adopted in that district. Some years ago the French coal-proprietors adopted the plan of building barracks near their pits, in which a number of people could be lodged on a small area; but the pitmen have shown so decided a preference for independent houses, and, if possible, for a bit of garden, that, during the last thirty years, pit villages of a very superior kind have been formed. It has been a prime object to attach the men to their localities by giving them comfortable cottages at a nominal rent, infant schools and primary schools for their children, and a pension* when incapacitated for work; whilst it has also been sought to remove, as far as possible, the temptation of public-houses, which in Belgium and in many places nearer home are a perfect curse to the working collier, and keep him in poverty, notwithstanding his good wages. The outcrop of the coal measures near Blanzy and Montceau is dotted with several colliers' villages overlooking a pretty valley. The houses are mostly two and two, surrounded by garden and court, each man having about 160 square yards of ground allotted him. Some of the miners, of a provident disposition, aspire to plots of land and to building houses of their own. The company has, therefore, purchased a tract upon which it grants building lots, and advances money to its workmen for building purposes, charging them no interest as long as they are engaged in the mines. The scheme has been attended by considerable success; and the rising village of Bois-Roulot, if not as regular and as well arranged in some respects as those built by the company, is, at all events, a serviceable means of lodging a tolerably large population, and a testimony to the steadiness of the men.

Within the last few years careful experiments, conducted by the Administration, have proved, what was long doubted, that France possesses coals excellently adapted for sea service; and for some time past no other than French coal has been used in the Imperial navy. But for these purposes the fossil fuels from different localities have to be judiciously selected and mingled in certain proportions. Taking the coal as a whole, it is noticeable that it makes much more small and dust than our own, and is more frequently apt to be "dirty" or mixed with shale and clay. It hence results that the French coalmasters have been driven to pay a special attention to methods of cleaning their produce and utilising the "slack," *menu*, or small coal. At the Great Exhibition in 1851, Bérard coal-washing machine came before us as a novelty, although it was only in certain details that it could rightly be so considered; and, besides several contrivances for that purpose introduced more recently, a great variety of ingenious apparatus has been brought into use for making "patent fuel," *agglomérés*—i. e., for pressing the small coal into cakes of various form by the aid of a small amount of some binding material. These *briquettes* are highly reported upon for naval use; in their carriage to the ports there is a loss of only 1 per cent., against from 6 to 10 per cent. on lump coal; and when stored abroad they are found after two years' exposure scarcely at all injured, whilst ordinary coal would have suffered to the extent of 50 per cent. Moreover, they are very free from ash, and may be made of a mixture of flaming and of dry coal, or of those varieties which have a more free-burning and a more calorific property respectively, in such a ratio as to give the best effect in getting up and maintaining steam. The present Exposition abounds with examples of the machinery and the products of this manufacture; and, although we are not in Great Britain without a similar industry, attention may fairly be called to the subject in the interest of the millions of tons of small coal

and of inferior qualities which we are every year actually getting rid of as refuse.

As early as 1833 Messrs. Marsais and Ferrand took out a patent for this purpose, but it was not until 1843 that the agglomerated coal began to be produced in any quantity, and some years more elapsed before the machinery was so far improved by several different engineers as to lead to the present large state of manufacture. The St. Etienne Company exhibit a model of their apparatus as employed at Givors, where, by introducing an enormous hydraulic pressure, they need only to add $\frac{5}{8}$ per cent of pitch (*brai sec*) to solidify the mass. The stack of rectangular blocks left outside the St. Etienne shed in the "park" throughout the heavy rains of April gave good testimony to the thorough compactness and durability which had been thus attained.

The greater part of the French makers appear to have adopted the circular arrangement of the Messrs. Revollier, and of Mr. Evrard and M. Dehaynin. A beautifully finished model is exhibited by the company of La Chazotte (M. Max Evrard, engineer), having sixteen cylinders disposed as the radii of a circle, in which the slack, after being heated by a current of steam and mingled by very ingenious apparatus with the pitch, is pressed by pistons and formed either into cylindrical or hexagonal blocks of convenient length. The rate of production appears to be in practice ten tons per hour with one machine (of which La Chazotte works four), requiring an engine of 50-horse power to work it, and the extreme limit of pressure being 100 atmospheres.

The prices of the St. Etienne compressed fuel are high; the first quality, which contains only 2.10 per cent. of ash, is marked at 28f. per ton; the second, with 5 per cent., at 26f.; whilst the best block coal rules at from 19f. to 23f., and the small at 9f. to 15f. The very small proportion of gas tar or pitchy matter introduced into the mass at this work can scarcely be considered as a general guide, since different qualities of coal will need some more, and some less, of binding material.

M. Felix Dehaynin, a producer of no less than 175,000 tons of *agglomérés* in the year, exhibits (in class 40) drawings of the Evrard machine, as modified by himself and employed at his three works, in which 500 people are engaged. The company called the "Océan," at Paris, are also exhibitors of drawings, and of the apparatus for the same purpose known by the name of its inventor, M. Mazeline.

As an adjunct in these operations, an ingenious machine, by Hanrez and Co. (Belgium, 12), may be noticed. It is constructed for the drying of small washed coal by the revolution of a screw within a revolving perforated cylinder, and is stated to dry five tons per hour.

We could wish that coal-workers, mineral landowners, and capitalists would note these various indications or what is becoming in France an important trade. Without being unmindful that several companies have been established in South Wales and elsewhere for a similar manufacture, we cannot but be conscious that their action is but an infinitesimal set-off against the wholesale waste of slack that takes place in this country. It is not only that the small coal cut and broken from the saleable part of the seams is, in most of our districts, thrown into goaf and gob by the tens of thousands of tons, but those portions of beds, often some feet in thickness, which are intermixed with stone or "sulphur," or which make a larger than usual proportion of slack, are at once rejected as useless, and acres of such coal are abandoned to be inextricably mixed up with broken roof and heaving floor, although of no worse quality than would be turned to advantage in many a French colliery. It is impossible, in the hard competition of the times, to blame individuals for this sin against the economical use of Nature's gifts; but it is a discredit to the country at large, and will, among our descendants, entail many an anathema on the selfish stupidity of their forefathers.

Boring, Rock-drilling, and Coal-cutting Machines.

All the world has heard of the artesian well of Grenelle; not many among the general public are aware of the striking success of the still deeper well of Passy, and but few are acquainted with the fact that at the present moment two undertakings of the same kind, on the grandest scale, are in course of execution—one in the suburb of the Chapelle, in the extreme north of Paris, by Messrs. Dégoussée and Laurent; the other at the Butte aux Cailles, in the extreme south of the city, by Messrs. Dru (formerly Mulot and Dru). These two firms, both noted for a great number of successful borings, exhibit an interesting assortment (57 and 58, France) of the apparatus which they employ for holes of diameters varying from 4 in. up to more than 5 ft.

The experience already acquired in supplying a portion of the French metropolis with excellent water tapped from that great reservoir in the strata of the green sand, hundreds of yards below the surface, has led the authorities to contract with thorough confidence for a further supply from the same bountiful source, and to commence the operations on a larger scale than before. In the absence of any great work of the same kind in London, we may remind those interested in hydraulic engineering of some of the chief features of the bore-holes already executed*:—Height of surface above the level of the sea at Grenelle, 121.3 ft. English; at Passy, 305.2 ft.; depth of bore-hole at Grenelle, 1800.7 ft.; at Passy, 1923.7 ft.; internal diameter of tube, or lining of hole, at Grenelle, approximately, 9 in. to 6 in. at bottom; at

Passy, 2.4 ft. The full diameter of the Passy bore-hole was 1 metre, or 3.28 ft. English; the new ones are to be, in one case above 5 ft., in the other about 4 ft., whilst it is proposed to pierce, not only to the water-bearing stratum, or *nappe*, already proved to exist, but to a considerably greater depth, in order to cut other feeders which probably abound in the subjacent measures.

It is a pleasure to be able to testify to the scientific knowledge and the business-like method which are applied to their task by the conductors of these two interesting operations. Both are alike in some general respects, such as the use of rigid rods only, in preference to rope; the employment of steam to work the rods; and the erection of a lofty pulley-frame, or derrick (*chèvre*), in one case 52 ft., in the other 68 ft., high from the ground to the axis of the main pulley. But in the details considerable variations are noticeable. The free-fall cutter, for the use of which these eminent bore-masters are strong advocates, is made to detach itself by a different device, the movement is differently communicated from the steam-cylinder to the walking beam, and there are sundry other variations worthy of study. At the time the British juror and his deputy were courteously met on the spot by Messrs. Dégoussée and Laurent, the work was unavoidably standing; but various of the implements were put together and lowered and raised to show the facility with which the heavy weights are dealt with. Engineers who visit the Exhibition only will be able to form some opinion of the nature of the work on seeing the great tower-like tube of rivetted iron plates, 1 centimetre thick each, but doubled, which forms a tall, black background to the well-arranged group of tools and models in the gallery of machinery.

At Messrs. Dru's bore-hole the depth, at the end of April, was near upon 500 ft.; the depth cut in the last working-day, in chalk and flint, was 94 centimetres. The weight of the boring-tool is above 2 tons 18 cwt. The rods are for the most part of wood, with iron connexions; and a length of 20 metres, consisting of two rods of 10 metres each, is raised or lowered at a time.

The magnitude of these operations for artesian wells is greatly exceeded as regards diameter, and therefore weight of apparatus, by the remarkable boring of actual shafts, which has in several cases been successfully completed by Herr Kind. It is matter of notoriety that the sinking of deep pits through difficult ground is, upon the ordinary and even most improved system, a wearisome and expensive task. In the North French coal-field it is estimated by Burat that a capital of 120,000f. is expended in the opening of a colliery fitted to raise 100,000 tons per annum, and the examples of Douchy and Aniche were cited, in each of which a still larger proportion of capital has been laid out. A serious part of this, amounting roughly to about half, is due to the sinking and fitting of the pits. And we know that, in consequence of the difficulty of piercing through the strata overlying the coal in Durham, sums of 40,000f., 60,000f., and, it is even said, 100,000f., have been expended on a single shaft. We have now, for the future, when so much of our most accessible coal has been exhausted, in a great measure to look to workings further in "the deep" for further supplies, and to shafts sunk through greater depths of Permian and other superjacent formations; and with us, as on the Continent, the problem of sinking with more rapidity and economy is one of the highest moment. We would, therefore, point to No. 53, France, as well deserving of the gold medal which was awarded by the jury, and of careful attention from colliery viewers. The coal company of St. Avoird and L'Hôpital (Moselle) have, under that number, exhibited diagrams of the results at which they have arrived, and some of the actual apparatus employed in the sinking of pits through a great thickness of watery new red sandstone which overlies the coal measures. The system, we should premise, is not altogether new. Some years ago both Kind and Mulot had undertaken to bore shafts of diameters of from 10 ft. to 16 ft., through ground whose "running" nature, like quicksand, prevented the application of the usual modes of pumping out the water and establishing the casing, technically called a tubbing, based on firm and water-tight strata. The excavation was therefore carried on by the borer à niveau *plein*, or with the shaft full of water; and the chief difficulty lay in the jointing, at last, of the iron or wooden lining with the firm ground at the bottom. M. Chaudron, a Belgian engineer, devised for this purpose a sliding piece at the bottom of the tubbing (the whole of which is gradually lowered as the excavation proceeds), on the bottom flange of which, turned outward, is a packing of moss, *boîte à mousse*; and when this latter comes to rest on the seat cut for it by the boring tool, the tower of tubbing, hitherto suspended from above, rests by a corresponding flange on the moss, and so squeezes it together and against the side of the pit as to make a tight joint, after the completion of which the water can be pumped out and the sinking commenced in the common way. Such is the bare outline of the method. Concrete (*béton*) may have to be run in behind the tubbing, and many other modifications adopted for insuring a perfect separation between the water in the pit and the world of water outside.

Already, in 1860, a signal success was attained by M. Chaudron in sinking an air-shaft at Péronnes, where the watery beds had extended from the 43rd metre to 105 metres deep; and M. de Vaux, Inspector-General under the Belgian Government, reported in 1861 that the work was executed for less than a quarter of what it would have cost under the ordinary method.

* The Anzin Company numbers at present, pensioned workmen, 856; pensioned widows, 455; in all, 811; besides assisting 218 orphans.—*Burat, Les Houillères de la France*, 1867.

* See report of M. Cassagnes, Portefeuille Economique des Machines, December, 1864.

A very ingenious addition of M. Chaudron's is a shield or diaphragm of sheet-iron temporarily fixed near the bottom of the tubbing and having a large pipe or equilibrium-tube in the centre, in which the water can rise, and through which the boring-rod passes down, having expanding arms which open out below the shield and excavate the ground. By this means the weight of the tubbing, which at Péronnes was about 88 tons, was so balanced as to throw only about 19 tons upon the rods employed for its suspension.

At St. Avoird, two pits have been thus triumphantly sunk, of which the sections are exhibited. No. 11 pit was sunk through 426 ft. of permeable red sandstone, *grès vosgien*; the final wedging-curb was fixed at 523 ft. deep, on May 1, 1866, and coal was found on April 4 last at 1036 ft. The second pit (No. 12) was so far complete that the "moos-box" was successfully laid, on February 3 last, at the depth of 521 ft.

The large models of the tubbing and shield, with the gigantic boring-cutters (*trépans*) of above 13 ft. across, will support this slight sketch in calling attention to an innovation which has been attended with a high degree of practical success, and which may hereafter facilitate the development of untold wealth.

Whilst for years past the vertical boring of deep holes, *sondage*, has been aided by the application of steam machinery, numerous inventors in all countries have attempted to solve the problem of applying the same power to supersede hand labour in the miner's daily task of boring holes for firing charges of gunpowder. The common operation, indeed, of drilling by borer and hammer small holes of from 18 in. to 3 ft. deep, by which at present all our hard rocks have to be blasted, is exceedingly laborious, slow, and expensive. Those engineers who have attempted to ignore the value of powder, and to cut the hard stone bodily away, have always failed lamentably. Others have endeavoured to imitate the action of the present hand-borers or drills; but the attempts hitherto made in this country to introduce the apparatus into mines have resulted only in delay and disappointment. There are, however, now in the Paris Exhibition two or three inventions which have passed the ordeal of practice, and have actually been employed in the daily service of mines. Since M. Sommeiller's successful application of single borers, each driven from its own cylinder by compressed air acting on a piston, a number of modifications of his general arrangement have been proposed, and it is to some of these that the attention of miners may be specially invited.

Mr. Doering, of Ruhrort, in Westphalia, mounts his machine on a horizontal arm projecting from a heavy iron carriage, which can be run to and fro on the rails in the level or gallery. The machine itself, consisting of a double-acting cylinder with piston, is, by means of pivoting and the motion of the horizontal arm up and down a vertical standard, capable of being set in any direction and at any height required. The drill, or borer, is attached by a key to the piston-rod, and is then by the action of compressed air projected and withdrawn several hundred times a minute against and from the surface of the rock, being turned through a small angle after every blow. A jet of water is constantly squirting into the hole for the removal of the debris, and so forcible and rapid is the action that I have seen several inches thus bored into a block of hard granite in five minutes. The bit, or cutting edge, of the tool may be varied; but the reversed Z shape, thus Z, as at Mont Cenis, is preferred, and it is found that it is blunted far less rapidly than when worked by hand with the blow of a mallet. And now for its practical application. One of the jurors, M. Max Braun, director of the great zinc-mines of Moresnet, near Aix-la-Chapelle, under the Vieille Montagne Company, stated to us that eleven of these machines, three of them on the newer construction, have been in actual use there; and that in a level in strong dolomitic rock, where they used to drive by hand-labour one metre and a half in fourteen days, they have with the machine made an advance of three metres and sometimes even four metres in the same time, and with only two men instead of six. The advantage, therefore, in the economy of the great standard expense of mining work is so obvious as to require no comment.

Another machine meriting attention for the same reasons is the "Bergborr maskin" of M. Bergström, exhibited by the mine of Persberg, in Sweden. The stand for it is a strong bar, with steel point at the bottom, and steeld holders regulated by a screw at the top; and as the boring cylinder traverses up and down the bar, this latter must be fixed by the aid of cross timber, in a direction parallel to that of the intended bore-hole. The drill is then made to act by compressed air in a manner generally similar to the last, although there are considerable differences in the construction. The weight of the whole apparatus is only 120 lb., and it may thus easily be moved from place to place, although open to the objection of giving more trouble in the fixing. The very machine which is exhibited is stated to have worked for 700 days underground, and to have bored 1000 metres. When tried upon hard granite it has bored 2 metres in the hour; and, as in Doering's machine, the "bit" has been found to last five times longer than when struck by hand.

A third modification of this general type is the machine exhibited by General Haupt, an American. It is mounted between two upright bars, which are fixed between floor and roof, and thus does not admit of the same scope of direction as Doering's. The movement of the piston or drill is effected by steam; but whilst the jury were making their inspection it never could be brought into steady

action. The valve arrangements are particularly ingenious, and the moderate size and weight of the apparatus are in its favour. A highly laudatory pamphlet accompanies this "perforator" to Europe, but does not contain any distinct statement of the machine having been actually employed in mining operations.

A very beautiful horizontal cylinder-engine is exhibited by M. De la Roche Tolay, engineer of the Chemin de Fer du Midi, intended to bore the rock by a rapidly rotating drill forced forward by hydraulic pressure of about 1540 lb. Various forms of cutting drill have been experimented upon, but the only one which appears to have given good result in hard rock is the diamond-mounted ring of M. Leschot. And, however preposterous it may sound to apply the valuable gem to the boring of holes in granite and quartz rock, visitors to the Exhibition may see it actually perform its work with considerable rapidity, and observe from a large drawing on the wall near it how it is proposed to arrange several of these machines at once for attacking a tunnel face. The boring implement is tubular, and admits a jet of water through the middle into the hole; its face, of soft iron, is studded with eight pieces of black diamond, carefully hammered up; and the incomparable hardness of the adamant encounters with such success the hardest materials of common rock, that the engineer states the cost of the abrasion of diamond for a hole of half a metre deep to be under twopence. Very many experiments have been made at surface, but it is not asserted that the machine has been subjected to practical trial underground.

The tunnelling machine, by Captains Beaumont and Locock, R.E., impelled by compressed air, and looking a "monstrum horrendum ingens," has already attracted much attention from visitors to the gallery of British machinery. It is a heavy powerful means of projecting against the face of the rock a disc armed at its circumference with thirty-six borers, which, gradually turning with the disc, cut an annular groove, whilst a central borer at the same time drills a hole of equal depth, which is afterwards to be charged with powder and fired. Whatever engineers may think of it for abbreviating the labour of tunnelling, it is too cumbersome, and, for various reasons, inapplicable for ordinary mining.

There is yet another machine to be mentioned which has done good service in economising labour and in preventing waste in the marble quarries of Rutland County, Vermont, U.S. It is the invention of Mr. Wardwell, and is exhibited in full size, in the outer shed of the United States department, by the Steam Stone-cutter Company, of New York. The machine, propelled by a small steam-engine of 4 horse power, consists of a carriage of 5 ft. in width, carrying on both sides a series of vertical bars armed with cutters which notch out a groove of the required depth instead of its being cut by the picks of the quarrymen. It is asserted that in these extensive quarries, where many hundreds of men used to be employed, the action of this machine, in reducing the labour cost and saving the marble by the narrowness and greater accuracy of the cut, has been eminently satisfactory.

Coal-cutting Machines.

Of far greater importance to this country are the attempts which for several years have been made to replace by machinery the labour of holing, kirving, or under-cutting the seams of coal. The purely mechanical operation of cutting, by means of a light pick, a groove of from 2½ ft. to 4 ft. deep along the face of coal which is to be removed is not only slow and laborious, but wasteful, as cutting into slack a considerable amount of the seam; and, forming as it does the chief item of expense in the excavation of the coal, it has of late been more seriously forced upon the attention of coal-owners by the irregularity and strikes of the workmen, which have so often brought the operations of the coal-mines to a ruinous standstill.

The earliest of these machines which may be pronounced a success is the pick-machine of Messrs. Firth and Donisthorpe, worked by compressed air. I had the advantage of seeing it doing excellent work by way of trial in 1863, at Hetton, and I am informed by Mr. Lindsay Wood, now managing that great colliery, that two of them have been daily at work for upwards of four years, and that they have given entire satisfaction. More of them would have been employed, but for the difficulties which arise in practice of adapting to them a special mode of work which shall also suit the particular character of the roof. Two newer machines are exhibited at Paris, which deserve special notice. Messrs. Jones and Levick, of Blaina (Great Britain, 8), have constructed a very portable carriage, movable along rails by a hand-wheel, and mounting a pick at any required height in the seam, so carried in a revolving head-stock that, instead of only striking horizontally, as in most of the earlier inventions, it may be applied to any angle of inclination in which the seam lies. A pressure of 30 lb. to 87 lb. is applied, through flexible tubes, and from sixty to seventy blows per minute are given, with a result, when all is in order, of undercutting to the depth of 3 ft. or 3½ ft. along a length of 9 yards to 15 yards in an hour. This would appear, on the face of it, to be a substitution for a great number of men; but other important advantages are gained. A better proportion of large coal is obtained, and the holing groove being very much less high in the front than where the hand-pick is employed, a comparatively small quantity of coal is cut into slack.

These advantages are also shared by the machine of Messrs. Carrett, Marshall, and Co., of Leeds (Great Britain, 3), a more complicated apparatus, the chief feature

of which is a strong steel bar, armed with three cutters or scoops, and forced by hydraulic pressure against the coal in such wise as to form the undercut by a sort of planing action oblique to the face. Instead of passing three times along the front of the coal, as do the pick-machines, in order to cut inward to the required depth, this contrivance completes the full depth at once, and without percussive action, or making dust and noise; it moreover cuts through iron pyrites and band-stone with facility. Mr. J. Liddell, of Newcastle, has kindly informed me that he has had one at work occasionally, and experimentally, for twelve months; that, when in full order, it has cut as much as twelve yards in an hour; but that, from circumstances in the seam of coal, the mode of working, &c., he is not yet in a position to give definite results as to the economy of its use.

It is unnecessary to dwell at length on the various ingenious arrangements which have been applied to these machines, but we may point with satisfaction to the inventions of our countrymen which are likely to aid in maintaining our position as the first producers of cheap coal; and the importance of the subject is further shown by the liberal offer of the colliery proprietors of South Lancashire and Cheshire to give prizes of 500*l.*, 200*l.*, and 100*l.*, for the first, second, and third best coal-cutting machines which shall have been fairly tested by their committee, in trials to commence in November next.

Coal-pit Fittings.

Whilst our British producers of mineral deemed it not worth their while, for the sake of a medal and a small modicum of glory, to incur the trouble and expense of sending over to Paris the familiar forms of apparatus which they employ, a number of French and Belgian coal-owners have forwarded models and full-sized fittings, which, if they have nothing specially new about them, yet play an important part in showing the present position of the mechanical arrangements brought to bear on their mines. Thus, the Company of Béthune (Pas de Calais) exhibits, in its full size, a stout pit-head frame, with flat-rope pulleys, wooden guides, cages, and tipping arrangements, all of them very similar to examples which we may find at home. The colliery is an interesting one, as being founded on that portion of the northern coal-field which has been so skillfully explored beneath its complete covering of the chalk formation, and being advanced to within a moderate distance of the Channel. Here, as in most of the recent establishments, the apparatus is on a good scale, and calculated to serve the purpose of working an extensive area from one set of pits. The Blanzly Company (Saône et Loire) represent in model another form of wooden frame, housed in, with a neat belfry-like roofing even over the sheaves or pulleys. A more novel construction is represented among the excellent collection of the collieries of the Loire (St. Etienne, &c.), placed in a special building in the park. The leg, beams, stays, and shedding are all of wrought iron, as erected at the pit of St. Louis, in 1864. A different system, that of building the main beams as cylinders of sheet iron, rivetted together, had in 1862 been adopted at the pit Jabin, and after four years of work stands perfectly well. The magnificent pit-head frames of the Forster pit, at Seaton Delaval, are known among us as a good example of wrought iron applied to this purpose, but the economy of the use of metal as compared with wood is not yet fully proved. The French fittings in wrought iron have been tried, on the observation of the engineers that, in their districts, six years are sufficient to render unserviceable the common head-stocks of pine, whilst ten years bring even oak to such a condition as to require expensive repairs. Pit ropes are exhibited of various forms and material. The heavy flat ropes of aloë-fibre are much employed in the north of France and in Belgium, where some of the shafts are of greater depth than any in our own country.

In the better collieries of both the above countries, cages of a construction similar to those of our northern pits are very generally employed for the conveyance of the tubs or wagons up and down the shaft. Many of these are exhibited in full size, some of them two-decked, to carry two tubs or wagons on one floor; others, for narrow shafts, having four tiers or decks for one tub each.

M. Libotte (Belgium, 16) shows cages for six tubs—one with two tiers of three tubs each; the other, of very awkward length, of six decks. The former weighed, when constructed, as usual, of rolled iron, 8960 lb.; the latter, 4180 lb. Simultaneously with what is doing in some of our Durham and Northumbrian mines, this engineer has been substituting steel for iron, in order to reduce the dead weight, and thus brings his new steel cages for the carriage of the same amount of coal to the more moderate weights of 2200 lb. and 2640 lb. respectively.

Ever since the Great Exhibition of 1851 numerous inventors have turned their attention to the subject of providing the cages with safety-catches, intended to grip the guides in case of the breakage of the rope. In 1855 and 1862 a long list of contrivances had to be reported upon; but, even up to the present day, the opinions of those most conversant with pit machinery are divided on the question of which of them, if any, is preferable to simply doing without them, if only due caution be exercised in employing the very best material and frequently overhauling the rope. It is matter for regret that none of our English inventors appear this time in the field, since Calow, Owen, White and Grant, Aytoun, and others, have devised various ingenious modes of attaining this important object, and many of our

English pits have been thus fitted or years past. There was nothing new to see on the present occasion. One of the oldest and theoretically perhaps a rather objectionable form, that of Fontaine, is still shown as in use at the great Anzin collieries, and merits respect from the number of lives it has actually saved. Jacquet, of Arras, and others exhibit a clutch acting by a toothed eccentric, similarly to that of White and Grant; and M. Nyst, of Belgium, his system of applying a pair of iron forks to trapezoidal wooden guides. M. Krauss, of Prussia, also exhibits what appears to be a good modification. Where the speed of winding is moderate, as in many of the continental and of our central and southern collieries, several of these varieties may do good service; but where the great velocity of Lancashire and the north is in vogue, the tendency of the clutches to come into play during the rapid descent is very troublesome and even dangerous.

Among safety lamps for fiery collieries several of the known modifications of the Davy are exhibited, and among them sundry contrivances for more effectually locking them than by the common method. A new one is that of M. Arnould, of Mons, who so inserts an iron pin that the lamp can only be unlocked by placing it in a proper position over the poles of a powerful magnet, and thus puts it out of the power of the men to expose the flame. Unfortunately, however, as we have too sadly seen in some of our late colliery accidents, all these precautions may be rendered utterly futile by the determination of colliers to carry lucifer matches in their pockets for the ready getting a light, when, against all rules and all prudence, they choose to strike it.

For the ventilation of mines nothing new has been proposed since 1862. But there are placed among with the fittings of the French collieries models of fine examples of the ventilators of Fabry, of Lemielle, and Guibal, the last two of which are now introduced with success into some of our English coal districts.

Dressing or Mechanical Preparation of Ores.

A variety of apparatus in this department is exhibited, little of which is characterised by novelty. The company of Fives-Lille (France, 55 and 87), whose engineers are Messrs. Huet and Geyler, make a considerable display in the gallery of machinery, of circular revolving tables, jiggling-hutches, &c., of iron, not without merit, and of some novelty to France, but following very closely the models of a well-known Prussian manufacturing house at Deutz, near Cologne.

The Austrian mining administrations of Przibram and Schemnitz have sent drawings and models of a number of useful inventions for the dressing of silver-lead and of gold ores. Most of them are the production of Mr. P. von Rittinger, whose able services in this direction have gained him a European reputation; and they have been already shown and commented upon at former Exhibitions. Our mining agents and engineers may, however, study with advantage the models which tell of his efforts to obtain continuous, instead of interrupted, action, especially in his jiggling-machine, and in the side-action percussion frame or shaking-table. Of the latter contrivance, two examples have been recently erected at the mines of the Vigna and Clogau Mining Company, North Wales, where they act admirably in separating the metallic sulphides, which occur along with the gold in their St. David's lode.

Amid the sad collapse and pressure which have for the last year or two weighed so heavily on our British copper and tin mines, simply in consequence of the large amounts of these ores which have been cheaply raised in distant countries, it is to be regretted that neither in this department nor any other of the actual processes of mining is our insular industry represented.

Apparatus employed in Metallurgy.

Omitting to notice several models of blast-furnaces, which offer no important feature of novelty, I should remark that the exhibitors from several different countries show that more attention is being bestowed on the economy of heat and on the utilisation of inferior fuels, by the introduction of gas-furnaces and of apparatus of the class of the regenerator of Messrs. Siemens. Some of the more interesting of these were contributed by Sweden, especially the elaborate model of M. Lundin, showing the method by which he obtains the inflammable gases from wet sawdust (which in vast quantity has hitherto in that country been a waste product), frees it from watery vapour, and then applies it to a steel-furnace, to brick-kilns, or other purposes. Lundin's arrangement would be applicable to the burning of such materials as wet peat, inferior coals, and lignites which are of very little or no value when tried on common fire-bars.

Among the extensive collections exhibited by Schneider and Co., of Creusot, in a special building in the park, some large drawings are well worthy of observation which illustrate the excellent arrangement of the enormous mills and forges and machine-making departments of that establishment. Some of the jury of our class, indeed, concluded (and it was the only subject on which we had a considerable divergence of opinion) that the distinguished Vice-President of the Chamber of Representatives ought to receive a *grand prix* for the success which had attended his efforts to produce from materials of only moderate quality manufactures of great excellence; and they held that the judicious arrangement of the various groups and divisions of the work contributed in no small degree to the economy of his finished products. And it certainly was no light

argument to point to the building, out in that remote south-eastern portion of France, of a whole army of locomotives for a British railway!

The French ironmasters have for years past enjoyed a reputation for the rolling of good qualities and particular forms of iron. In 1855 the capital iron girders which were being abundantly employed in the erection of common street houses aroused the interest of many of our jurors; and now, in 1867, the works of Châtillon and Commentry, and of Petin, Gaudet, and Co. distinguish themselves by the finest examples of rolled girders and plates that have been seen. To understand, in fact, how some of these beams of 1 metre high and with very broad flanges at top and bottom had been so well and evenly rolled, it was necessary to see the model exhibited by the former company (France, 88), showing on a small scale the complex arrangements of their universal mill, *laminoin universel*. Messrs. Marel Frères, the well-known makers of many kinds of machinery, exhibit a rolling-mill of the same elaborate character. It is placed near the boring apparatus of Dégoussé and Laurent. M. Wagner, the director of the works of Mariazell, in Styria (Austria, 5), also furnishes, although on a much smaller scale than the last, the model of a rolling-mill for the same purpose, as devised by himself. No doubt many of the products turned out by these machines, and shown in the Champ de Mars, may fairly be considered *tours de force*; but we cannot withhold from the French iron producers the credit of having attained by their skill and perseverance to a high grade of excellence.

Steam-engines for Winding and Pumping.

If there were any one department of machinery in which we Englishmen used to think, a few years ago, that we had it all our own way it was the construction of steam-engines. And although it might be conceded that taste was to be found across the Channel, and that good designs might be produced, and, perhaps, even light work executed by French and Belgian engineers, still it was confidently asserted that, for heavy work and for powerful engines, they must come to England. A glance at the Paris Exhibition will dispel these illusions, and teach us that machine makers and designers have arisen who have made good use of a sound education in mechanics, and who are competent to cope with the tasks daily brought before them by the progress of engineering.

Several large winding-engines for collieries are brought before us in full size, and exhibit the types which are now attached to some of the first-class works. Thus, M. Quillaq has erected an engine with two coupled vertical cylinders in front of the pit-frame of the Bethune Company, the piston-rods acting directly on the shaft of the drum or rope-roll. Belgium has sent two double-cylinder engines, each, like the last, of about 200 horse power. Both these, that exhibited by the Chatelineaux Company, and that of MM. Dorzée and Audry (Belgium, 19 and 6), have their cylinders mounted on a pyramidal iron framing, and working downwards upon the rope-drum, which is placed at the level of the ground. Something may be gained by this mode of construction in the economy of the engine-house, but several reasons might be adduced in favour of the opposite system, generally followed at our large collieries, of planting the cylinders low and mounting the drum above. These engines, as also the well-finished, powerful horizontal machine exhibited by the Creusot Company, are fitted with a special cylinder for a steam brake, and sometimes with an apparatus for arresting, independently of the engineman, the progress of the cage on its going dangerously high in case of inattention. One of these contrivances, a long horizontal screw, along which a carriage travels as the cage ascends, was already exhibited in 1862 by the maker, M. Gouteaux, of Gilly.

Some modifications of pumping-engines, which evince much ingenuity, are exhibited in drawing by M. Colson (Belgium, 5), but their merits can scarcely be pronounced upon without observation of their effectiveness in practice. The French engine-maker, M. Quillaq, of Anzin (Nord), not only exhibits his productions in drawings and actual engines, but excited the incredulity of some of the jury by a statement that he had supplied both pumping and winding steam-engines to an important Newcastle colliery. That such a Gallic invasion of our great centre of colliery operations should have taken place without some special reasons or private arrangement appeared highly improbable, and I at once communicated with the owner for the purpose of obtaining the explanation. It is but justice to the French engineer to state that the order for the direct-action pumping-engine which he supplied was given simply in consequence of his lower price and better finish as compared with the tenders from the English houses. It has now been at work above eighteen months, and I quote the particulars kindly sent me by the owner in saying that "it has given the greatest satisfaction," and that "the construction and the quality of material and workmanship are very good." This has led to the order of a pair of winding-engines for the same place, which are also "highly satisfactory." Here we have, then, one of our Newcastle mines actually working by means of French-made machinery, fairly brought in by open competition to the midst of our machine shops and foundries; and when we look at the inland position of Anzin, and the unquestionable disadvantages which have to be combated in a district where coal and iron are comparatively dear, I cannot but think these results redound to the credit of French engineering and inculcate on ourselves an important lesson.

CIVIL ENGINEERING, PUBLIC WORKS, AND ARCHITECTURE.

PARIS EXHIBITION. CLASS 65.

BY CAPTAIN PONSONBY COX, R.E.

ALTHOUGH there is no science which has given to the world such important practical results within the last few years as that of civil engineering, and though there is probably none which has made more real scientific progress, its recent progress and its later results are far from being adequately represented in the Exhibition of 1867.

In the French section only is there a satisfactory exhibition in civil engineering proper; the other European nations, as well as the United States of America, are but slightly represented. Our own country can hardly be said to be represented at all.

This is much to be regretted, for undoubtedly a well-assorted collection of models or drawings of the most important engineering works scattered all over the world which are due to the energy and skill displayed by English engineers within the last few years would, if placed side by side with the magnificent collection of models and plans in the French section, have formed an exhibition most interesting and instructive, would have added much to the available knowledge of civil engineering of the world, and saved much of the labour thrown away in re-inventing. From this point of view, the Paris Exhibition cannot but be looked upon as a great opportunity lost. The public works of London alone might have supplied admirable examples in the great railway stations and river bridges recently constructed, as well as the works connected with the main drainage and the Thames embankment. The materials for a good display exist no doubt in the works of Great Britain and her colonies, but we do not possess (nor does any other nation possess), for tabulating those materials, such a machinery as France has in her establishment "des Ponts et Chaussées," her "Ecole des Mines," "des Arts et Métiers," &c.

The French collection is unrivalled. It contains models, admirably got up, of bridges, viaducts, reservoirs, docks, tunnels, &c., with complete plans illustrative of all recent public works; a brief but clear report of each work is to be found in a volume published under the auspices of the Ministère d'Agriculture, du Commerce, et des Travaux Publics. From this source have been derived the figures which will be found in the short notice of some of the most important public works attached to this memorandum.

Leaving France for the present, we find the most important exhibit connected with civil engineering in the English section to be the application to lighthouses of the dioptric system of light of Augustin Fresnel, which system is now being generally introduced, both for fixed and revolving lights. The Trinity House and the Commission of Northern Lights have sent a series of models of lighthouses, light-ships, &c., and several lanterns of different sorts and sizes. These lanterns are all from the works of Messrs. Chance, of Birmingham, and comprise the improvements made by them as well as by Mr. Douglas for the Trinity House, and Messrs. Stevenson for the northern lights. The dioptric system has been recently admirably described by Mr. Chance in a paper read at the Institution of Civil Engineers. It consists of a structure of segments of glass enveloping a central flame whose focal rays are parallelised in a horizontal direction, and deflected in the case of fixed lights in meridian planes only, whilst in revolving lights the rays are gathered into a number of cylindrical beams which are made to pass successively before the observer by the rotation of the apparatus. The dioptric instrument is further described to consist of three main divisions; an equatorial belt of the sphere of light proceeding from the flame is acted upon by refraction, but the rays above and below this belt are deflected by total reflection; the relative illuminating values in the horizontal plane of these divisions of the part of the luminous sphere acted upon are in the proportion of, upper reflectors, 20; refracting portion, 70; lower reflectors, 10.

It is most important to send towards the sea horizon the brightest sections of the flame. The Trinity House Corporation exhibits the application of the magneto-electric light, for the discovery of which the world is indebted to Professors Faraday and Holmes; the former discovered in 1831 that a spark could be produced by magneto-electricity; the latter, that by this means a continuous flame could be kept up. In 1857 the discovery of Professor Holmes was first applied in the South Foreland Lighthouse. It has since that date been submitted to long practical trial, the result of which has been the determination to adopt it in other lighthouse stations.

The machine for the production of the light consists essentially of six brass wheels, with sixteen bobbins of insulated copper attached at equal distances to the circumferences of each wheel; inside each bobbin is a hollow core of soft iron; the wheels are all fixed upon a shaft, which is driven by a steam-engine. In turning, every core of each wheel is brought at the same instant between the opposite poles of two magnets, which pair of poles it also quits at the same instant. The core of every bobbin has its magnetism thus reversed by the revolution of the wheels 107 times per second. This reversing of the magnetism induces a current of electricity in the bobbins; the combination of the currents produces one of sufficient intensity to give a powerful light. The lantern in which the electric light is used was designed by Messrs. Chance, by whose arrange-

SUSPENSION BRIDGE OVER THE RIVER

MR. JOHN A. ROEBLI

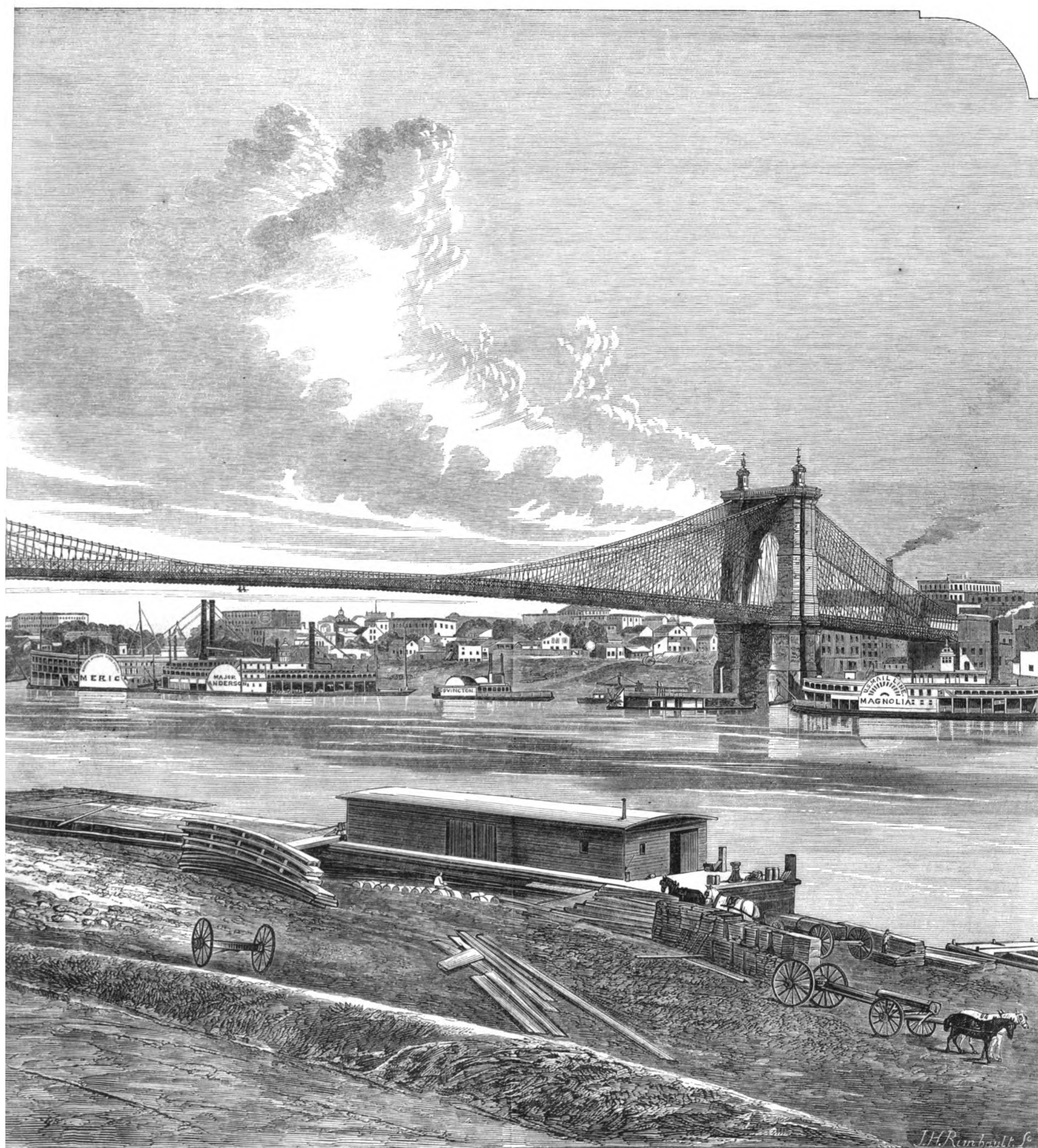
(For Description, 1867)



OHIO AT CINCINNATI. (1057 FT. SPAN).

ING, ENGINEER.

see Page 335.)



ment the bars of the lanterns are fixed obliquely, and by this means the amount of light stopped by the lantern is reduced to a minimum.

The above appear to be the most striking exhibits in the English section; and, indeed, there is little else calling for special notice in engineering, properly so called. Mr. H. Cole has sent a specimen of enamelled ceiling, which in many cases might be adopted with advantage; and the exhibits of ornamental tiles by Minton and Mawe, and of terra-cotta by Blanchard, Blasfield and Pulham, are prominent instances of improvement in materials of construction.

Messrs. G. Smith and Co. exhibit a specimen of the façade of the South Kensington Museum, showing an admirable combination of finished brickwork with terra-cotta mouldings and enrichments.

Turning to Belgium, we find in an annexe a model of the system adopted by M. E. Boucqueau in the construction of a tunnel on the line of railway from Brain le Conte to Gand. The tunnel, which is about 440 yards long, is carried through a hill on the bank of the river Dendre. It is approached on the north side through a considerable cutting, and the line at the south side is carried on an embankment. It was necessary, in order that the work should proceed with rapidity, that the tunnel should be attacked at several points at once. Sinking shafts from the ground above and lifting the stuff over the hill would have been attended with considerable expense. M. Boucqueau consequently determined to drive in a small gallery, parallel to the tunnel, at one side of it, and about 2 ft. below its general level. From this gallery adits were driven right and left at right angles to the axis of the tunnel. The whole of the *déblai* was taken out through these adits and disposed of at the south or embankment side of the hill; whilst the small gallery, being somewhat below the proposed level of the permanent way in the tunnel, kept the workings free from water. The gallery was 5 ft. wide by 6 ft. high. Its sides and ceiling were supported with sheet piling and lagging. The distance between the axes of the small gallery and the tunnel was 57 ft.; the branch adits were about 70 to 80 yards apart. A tramway was laid along the gallery, with turntables for the earth-wagons at the mouth of each adit. This system claims to have effected a considerable saving in time and money as compared with the plan of sinking shafts from the top; but it is probably only of exceptional applicability, as in most cases the ordinary system of working from a heading within the line of the tunnel itself would be less expensive.

Prussia exhibits a system of centering lately used in tunnelling, the essential feature of which is the substitution of a portable iron framework for the ordinary timber centering.

This system has been adopted in the construction of the tunnels of Narusen and Ippensen. The mode of employing it will be readily understood from the illustrations. A framework, consisting of cast-iron segments bolted together supports a second iron framing, which latter is formed of railway metals, bent to the form shown, and fitted together with radiating joints, like the *voussoirs* of an arch. These two frames form the principals of the centering. The upper *voussoirs* are attached to the lower frame by clips, which overlap the lower flange of the railway metals of which they are formed. The *voussoirs* can be removed one by one as the masonry of the arch is brought up to replace them.

From the soffit of the iron principals are suspended hanging pieces, also of railway iron, which support cross bearers carrying tramroads in two or three tiers, as may be necessary, to remove the excavations and to supply the materials of construction.

The advantages claimed for the system are that, from the interior space being not hampered by uprights to carry the principals, as would be necessary if wood were used, the work can be carried on with much greater facility; it is easier to range out the line and to work truly, to ventilate the tunnel, and to get rid of water. The first cost is stated to be very little, if at all, above wooden centerings; and, from the greater durability of the materials, it is stated in the long run to be more economical. It is open, however, to the objection that unequal pressure of the surrounding earth, if sufficient to fracture the centering, would produce much more serious damage than with the ordinary systems in use. The design is by M. Franz Rziha.

In the southern States of Germany a remarkable example of cheap railway-bridge construction is exhibited in the Bavarian section, by a model, on a scale of $\frac{1}{160}$ th full size, of a bridge of boats over the Rhine, between Maximiliansau and Maxau, which carries a loop-line of the Karlsruhe and Winden Railway, opening up a considerable local traffic, and carrying the coal trade between Bavaria and Baden. The main line crosses the Rhine at the bridge of Kehl.

The road traffic at this point was formerly carried over a bridge of boats, situated about half a mile higher up the stream than the present one; this has since been removed, and the ordinary as well as the railway traffic crosses the new bridge.

The Rhine at Maxau is 240 metres wide; its bed, which is of gravel, is constantly influenced by the deposit brought down by the current, the navigable channel being thereby shifted alternately to the Bavarian and Baden bank. This cause has made it necessary to make two parts of the bridge, one on each side, movable, to allow the passage of the river traffic. The bridge is at right angles to the stream; its

length over all is 362.80 metres, of which 234 metres is actual bridge, the ramps of approach from each shore being 64.10 metres in length. These ramps are supported upon timber stages, and their gradient can be regulated by a system of screw gear to suit the level of the stream. The recorded readings of the Rhinometer at Maxau show the extreme range of variation of water level to be 5.10 metres—i.e., between 3.60 above and 1.60 metres below the zero of the scale. These extremes have, however, been but rarely reached; the mean level of the Rhine is 2.50 metres on the scale, and this height of water gives an ascending gradient of 1 in 60 to the approaches to the bridge; the extreme reading of 3.60 metres on the scale giving a gradient of 1 in 30.

The bridge consists of twelve rafts, six of which are easily removable to allow the passage of boats; these rafts are carried by thirty-four pontoons, or boats, substantially built of oak, of which material are also the principal beams and the upper planking of the roadway. These pontoons are 65 ft. 6 in. long, 12 ft. 2 in. broad, and 4 ft. 7 in. deep; except the two pair next the shore, which are somewhat larger.

In order to allow the permanent way to adapt itself to the rise and fall of the water level, as well as to the deflection of the roadway from the immersion of the pontoons, on first taking the weight of the train as it leaves terra firma, the joints of the longitudinals and the metals which they carry are made with a hinge where their shore end and bridge end abut, besides which these ends are each borne upon a strong coach-spring.

The general arrangement of the bridge, the position of the movable rafts, and the method adopted of attaching the various parts to each other, will be readily understood.

This bridge was designed by M. Basler, engineer in chief of the railways of the Palatinate. The total cost of its construction was 12,000*l*.

In the Italian section is an atlas containing plans and sections of the great tunnel of Mont Cenis, which is being constructed, as is well known, to unite the Paris-Lyons and Mediterranean Railway with the Italian railways, so as to establish communication with an unbroken gauge between Calais and Brindisi, a distance of 1390 miles, and to annihilate the danger and difficulties of crossing the Alps; which, will, however, be much reduced, long before the completion of the greater work, by Mr. Fell's summit railway. The entrance on the French side, about $1\frac{1}{2}$ mile from Modane, is 439 ft. lower than the Italian end at Bardonnèche; this would give a gradient in the whole length of the tunnel (7 miles 1007 yards) of 1 in 91 nearly. The tunnel is not, however, being executed at a uniform gradient; a fall is given towards both ends from the centre of 1 in 2000 and 1 in 45 respectively. The works, which were commenced in 1857, were first carried on by manual labour. During 1858, 844 ft. were thus driven at the Bardonnèche end; this was the greatest progress which has been made by manual labour in one year. The works are now being carried on with boring machinery driven by compressed air, motive power being obtained by water at the French side from the river Arc, at the Italian side from the river Mezelet, from which sources the water is led to reservoirs. Since the adoption of machinery, the progress has been much more rapid. In 1865, the length driven amounted to 2502 ft. on the Italian side.

Commencing from the French end, the first 2350 yards have been through schist; then 550 yards of quartz were encountered, through which the progress was very slow. This has been cut through, and the tunnel on the French side is now through limestone, which is not quite so difficult as the quartz. The present progress through the limestone is about 1 yard per day; through the quartz it hardly reached 2 ft. After passing the limestone, schist is again reached, which formation extends to the Italian end. It is now stated that the probable date at which the excavation will meet will be some time in 1873.

The public works recently executed by the Italian Government are also shown in an atlas of plans; but they are principally military barracks, and do not appear to be very important or to possess much general interest.

The most important work of civil engineering shown by Spain is the breakwater of Tarragona, of which there is a sectional model.

This work, which is still in progress, can lay claim to priority in point of age to any work of civil engineering in the Exhibition; its commencement dates as far back as 1790.

It is intended, when finished, to be about 1500 yards long, with a total width at top of 100 yards, including a pier on the inner side of 65 yards wide; the base of the breakwater is nearly 300 yards wide. It is formed of *pierre perdue*. Some of the blocks in the base are of enormous size; their interstices are filled in with smaller blocks; the top stratum is of concrete up to the level of the pier. The work has been carried out principally by convict labour.

It is in the French section, as has been already stated, that we find by far the most important exhibition of works of civil engineering. France undertakes to tell us what her engineers have been doing during the last few years; she shows immense progress in the science. A careful study of the admirable collection of models and plans exhibited by the Public Works department cannot fail to produce the conviction that the works they represent have been most scientifically designed, and executed with great care, great practical skill, and economy. A very slight description is

given of a few of the most remarkable of these works. The first selected for notice is the great swing bridge at Brest, which spans the inlet of Penfield between the town of Brest and Recouvance. Two models—one on a scale of $\frac{1}{160}$ th full size of the whole bridge, another $\frac{1}{160}$ th full size of one of the piers—exhibit the construction. This bridge has a greater span than any bridge of similar construction in the world; it is well and solidly constructed, and has stood the wear and tear of ten years without any considerable repair.

The distance between the sea-face walls of the Penfield (571 ft.) is spanned by two wrought-iron lattice frames, revolving upon turntables which crown two circular towers, 34 ft. 9 in. in diameter and 347 ft. apart in the clear: the latter dimension is the total width of the fairway of this part of the naval harbour. Each of these two frames consists of two girders, 25 ft. 4 in. deep over the piers and 4 ft. 7 in. deep at the centre; these are strongly braced together with perpendicular and diagonal braces, and support the roadway, which is itself constructed so as to add considerably to the rigidity of the structure.

The shore ends of the frames form a rectangular box, which contains the counterweights of the bridge. The total weight borne upon each pier is 590 tons; the turntable on the summit of each pier is 29 ft. 6 in. in diameter, and has fifty rollers, each 1 ft. 7 in. in diameter and 1 ft. 11 in. in length. The means of opening and closing the bridge is extremely simple; it consists of a pinion fixed to the revolving part of the bridge, gearing into a horizontal cog-wheel on the pier. The motion is transmitted by an intermediate to an upright shaft, which comes up through the roadway of the bridge, and is crowned with a capstan. Four men with capstan-bars can open the bridge in ten minutes. Should it be necessary to repair or replace any of the trucks, or any other part of the mechanism of rotation, the whole weight of the bridge can be lifted off its bed by means of four hydraulic presses in the centre of the piers.

The foundations of the piers are on the solid rock. They are built of rubble masonry, faced with ashlar. The sea walls are of rubble, with dressed quoins; the weight of the metal used in the construction of the bridge is 1180 tons.

The total cost, including foundations, was 85,000*l*.

The design was by M. Oudry; the works were carried out by MM. Schneider and Co., of Creusot.

A very remarkable exhibit by the Ministère des Travaux Publics is a model ($\frac{1}{160}$ th full size) of a masonry arch designed and built by M. Vaudray, engineer of the "Ponts et Chaussées," as an experiment preliminary to the construction of a bridge over the Seine, to connect the Rue du Louvre and the Rue de Rennes. The bridge in question had to span the river exactly over the locks of the Canal de la Monnaie; and the necessity, on the one hand, of keeping the springing of the arch above the lock walls, and on the other, of keeping the level of the roadway down to the existing level of the streets leading to it, confined the rise of the arch to a height not exceeding 7 ft., whilst its span had to be nearly 125 ft.

In order that the new bridge should be in keeping with the numerous important public buildings in its vicinity—viz., the Pont Neuf, the Louvre, the Hôtel de la Monnaie, &c., it was very much to be desired that it should be of stone; and, the possibility of building so flat an arch with the span required in that material having been questioned, it was determined, before carrying out the project, to build an experimental arch which should fulfil the required conditions. The spot selected for the experiment was the quarry of the plains at Soupes, sixty miles from Paris, on the Bourbonnais Railway. The natural quarry face of the rock was shaped to form one abutment; the other was a massive block of masonry built for the purpose.

The description and general dimensions of the arch are as follow: Its form is a segment of a circle, of which the chord is 124 ft., the versed sine 6 ft. 11 in. It is built entirely of cut stone; the number of the *voussoirs* in each ring is seventy-seven, diminishing in depth from 3 ft. 7 in. at the springing to 2 ft. 8 in. at the keystone; the beds and joints of the *voussoirs* are dressed with the greatest care, and are laid in Portland cement mortar, the composition of which is two parts sand to one part cement. The thickness allowed to the mortar joints was $\frac{3}{8}$ in. The joints next the skewback were not flushed until after the completion of the ring, having been meantime kept open with fir wedges.

The artificial abutment is 27 ft. in height, 49 ft. in mean thickness, and 12 ft. wide (this is also the width of the arch); it was built of rubble masonry, well bounded together and laid in Portland cement mortar—one part of cement to three parts of sand; its construction occupied twenty days; the laying of the *voussoirs* seventeen days.

The arrangement for striking the centering was by the means of dry sand contained in iron cylinders, hereafter described. This method, it will be observed, is peculiarly well adapted for so critical an experiment as the one under notice. Arrangements were made to observe with the greatest exactitude the effect which should be produced on the arch by the removal of the centering. The arch was left to set four months; the centering was then eased by allowing the sand to flow regularly from the cylinders. In an hour daylight was perceptible between the soffit of the keystone and the lagging; in two hours the arch and the centering were quite separate. The result upon the arch was then found to be as follows:

The crown had come down $\frac{1}{160}$ th of an inch, the joints of

the skewback had opened on the built abutment side $\frac{7}{1000}$ ths of an inch. After the lapse of three days the arch was observed to have come down $\frac{7}{500}$ ths of an inch more.

It was then loaded with a weight of 860 tons, disposed over the whole surface of the roadway; the loading occupied thirteen days. When complete, the crown was found to have come down $\frac{7}{500}$ ths of an inch.

Since then nothing has stirred. The arch was afterwards tested by a weight of 5 tons being allowed to fall on the roadway vertically over the keystone from a height of 1 ft. 6 in., but no joint has opened, nor has the bridge sustained the slightest injury.

This interesting experiment satisfactorily proves that the relative proportions of rise to span in large masonry arches to which engineers have hitherto limited themselves may be largely modified; it is quite clear, however, that such constructions require very accurate work and the greatest care in execution.

Allusion has been made above to a method of easing and striking centering by means of sand. A full-sized model in the park shows this method, now frequently adopted by French engineers for easing large centerings from arches on completion of works—viz., by resting the principals of the centering upon sand contained in iron cylinders, from the bottom of which the sand is allowed slowly to escape.

Each principal is supported upon round props, fitting as a piston into a cylinder, containing fine dry sand.

The cylinders are of sheet iron, $\frac{3}{4}$ in. thick, 1 ft. high, and 1 ft. in diameter. About 2 in. from the bottom they are pierced with holes about $\frac{1}{2}$ in. in diameter, which are stopped with common corks. To ease the centering the corks are removed, the sand then escapes through the holes, until a cone of sand is formed at the base of the cylinder. The formation of this cone arrests the further escape of the sand, and therefore the descent of the piston, until the cone is swept away, when it re-forms. The sweeping is repeated until the piston has descended sufficiently to detach the centering from the masonry.

By taking care to sweep away the same cones simultaneously, the lowering of the centering can be performed with perfect evenness, and as gradually as may be desired by $\frac{1}{1000000}$ of an inch, if necessary; whilst, as no force whatever is required to be used, the arch is not subjected to the slightest shock during the operation. This system was originated by M. Beaudemoulin, engineer in chief. It has been applied to many important works; amongst others, to the fine bridge of Austerlitz.

Three fine examples of engineering are exhibited in models, $\frac{1}{100}$ th full size, of the three iron railway viaducts of Busseau d'Aun, la Cere, and du Midi; they are all three of the same type. One of them is the viaduct of Busseau d'Aun, which carries the Chemin de Fer d'Orléans between Montluçon and Limoges across the river Creuse, close to the junction of Busseau d'Aun.

It is composed of a lattice girder in six spans, supported upon iron columns, surmounted upon masonry bases.

Each of the five piers consists of eight hollow cast-iron columns, in two rows of four (transversely to the roadway), crossbraced horizontally and diagonally with rolled iron joists; these piers support four main lattice girders, connected by cross girders, bearing a timber floor and continuous sleepers.

The eight columns of each pier batter towards a point 148 ft. above the roadway, thus forming a four-sided truncated pyramid; the same batter is given to the masonry bases upon which they are mounted; this arrangement gives a very pleasing effect to the structure. The bases are rectangular blocks of ashlar, with dressed quoins carried up from the rock; the iron superstructure is secured to them by eight holding-down bolts of $\frac{3}{4}$ in. diameter round iron.

The work of erecting this viaduct was performed with great skill; the main girders were rivetted together on the bank, and launched into place without the use of scaffolding; this was effected under the direction of M. Moreaux. The design of the viaduct is due to M. Nordling. Its total cost was 60,000*l.* sterling.

The fine and well-proportioned iron lighthouse in the park has been constructed by M. Rigolet, of Paris, from the design of M. Reynaud, Inspector Général des Ponts et Chaussées. It is destined for the rocks called "Les Douvres," situated midway between the islands of Guernsey and Brehat, off the coast of Brittany.

The rock on which this lighthouse is to be built is in the middle of the south edge of the shoal; its summit is awash at high tide. The masonry foundations of the lighthouses are 6 ft. 10 in. high; the height of the iron column is, from base to floor of gallery, 158 ft. 6 in.; to top of lantern, 184 ft. 2 in. In plan it is a sixteen-sided polygon. The diameter of inscribed circle at base is 36 ft. 6 in.; at top, 18 ft. 2 in. The light is 174 ft. above high-water level.

Round the base of the column are the store-rooms and living-rooms of the lighthouse keepers; above these are rooms for the reception of persons rescued from shipwreck. In the centre of the column is a cast-iron staircase from the base to the lantern.

The chief peculiarity of the construction of this lighthouse is that the structure depends for its strength wholly upon its skeleton; the iron plates which are attached to it are merely a skin, and are not at all relied upon for strength; whereas in wrought-iron lighthouses of ordinary construction strength is obtained by the rivetting together of the plates of which it is composed. The reasons which

M. Reynaud has given for this departure from usual construction are—1, that plate iron is liable to rapid decay from oxidation; 2, the ordinary mode of construction necessitates special appliances and scaffolding, &c., not easy to erect upon a rock situated as is the Douvres, whereas he has been enabled to arrange the parts of his structure so that it can be put together on the site with great facility. The skeleton of the structure consists of sixteen frames, forming the sides of the polygon, fifteen panels high. Each panel is formed of $7\frac{1}{2}$ in. by $8\frac{1}{2}$ in. T iron, securely rivetted together. These panels are bolted each over each, and strengthened at their edges by a binding piece of 7 in. by $8\frac{1}{2}$ in. T iron bent to the shape of the polygon. The skin is $\frac{3}{4}$ in. plate iron at the base, diminishing to $\frac{1}{2}$ in. at the summit of the column. The joints of the plates are overlapped with strips of $\frac{1}{2}$ in. iron. The balcony of the lantern is carried upon cast-iron cantilevers. The light is dioptric, revolving upon ten steel friction-rollers upon a hardened steel tread-plate. The supply of oil is regulated by clockwork, manufactured by M. Lepaute, of Paris.

The weight of the lantern is about 4 tons. The total cost of construction was (including erection in the park and taking down hereafter) 10,000*l.* sterling.

The tunnel of Ivry, a model of which $\frac{1}{100}$ th full size) is exhibited, is chiefly remarkable for the skilful manner in which the difficulty of obtaining a secure foundation for the masonry of the tunnel has been overcome.

This tunnel carries the girde railway of Paris beneath the Champ de Mars of Ivry, and is 220 yards long. Its permanent way is about 40 ft. beneath the surface of the ground. The formation through which it is driven is sand, above a marl bed, which overlies a stratum of calcareous stone, good for building purposes, and formerly much used in constructions in Paris. The quarrying of this stone has left considerable cavities beneath the site of the tunnel, which have necessitated the precautionary measures for securing its foundation shown in the model.

To carry down the side walls of the tunnel to the solid floor of the quarry, as first intended, would have involved immense expense; and as it was found that the stratum which intervened between the required level of the permanent way of the railway and the excavations beneath was of a solid nature, it was determined to shore it up from below with masonry walls, exactly beneath the site of the side walls of the tunnel, and to fill up the cavities between these lower foundation walls with rammed earth. To effect this, two galleries were driven beneath and parallel to the intended tunnel; these were lined with masonry walls, so placed that one (the thicker of the two and the nearest the axis of the tunnel) should coincide in plan with the side wall of the tunnel, and should support the stratum of rock upon which the latter should be built.

These minor galleries were arched in, and served as galleries of inspection, by means of which the foundations could be examined both during the progress of the work and after it had been tested by the passage of trains. Many difficulties occurred in the execution of the work, owing to the ground having been largely fissured by faults in the quarry veins. A serious obstacle was met with, owing to a part of the old quarry having caved in beneath the superincumbent earth. The earth which had slipped had assumed the form of a truncated cone of about 80 ft. in diameter at base and 15 ft. at its upper surface. In order to carry the foundation gallery through this fault, it was necessary to support the whole circumference of the slip upon masonry carried up from the solid rock. This done, the whole of the loose déblai was removed through the gallery of inspection, and piers being then built up at the extreme edge of the slip, an arch was thrown across the space, and the pier-wall of the tunnel built upon it. It will be readily seen that this was a critical and difficult piece of work. It was carried on night and day, in reliefs, under the direction of M. Bassompierre, engineer in chief des Ponts et Chaussées.

An extremely ingenious system of syphons recently applied in France to large reservoirs for the purpose of getting rid of the surplus and storm waters is shown by two models, one of $\frac{1}{100}$ th full size, and another of the head of the syphon-feeder $\frac{1}{100}$ th full size.

The system presents some novelty, has been found to work well, and it is intended to apply it to other reservoirs in France.

The apparatus consists of two cast-iron syphon-pipes, 27 in. internal diameter, $\frac{1}{8}$ in. thickness of metal, through which the surplus waters are discharged. To these are attached two lesser auxiliary pipes, whose internal diameter is about 4 in. These latter communicate with the larger pair at the highest part of their curve, and are the means by which the discharge is regulated.

In order to protect the apparatus from frost and from injury from any other cause, it is inclosed in a masonry chamber formed in the dam, and communicating with the reservoir by a port, *a*, which is usually open; it can, however, be closed for repairs, &c. There is a second port in the chamber which is closed by a sluice-gate, *c*. This is only opened to empty either the chamber or the reservoir. The upper part of the auxiliary pipes or feeders, which have been described as being attached to the larger pipes, does not communicate directly with the reservoir. This upper part is within the masonry chamber, about $\frac{1}{4}$ in. above the prescribed water level of the reservoir. Its attachment to the pipe is by means of a water-tight expansion-joint, which allows it vertical play. As long as the reservoir is at below

its prescribed water level the syphon is inactive; but as soon as it rises above that level it begins to flow away through the small pipe, and, the water continuing to rise, the head of the latter becomes completely submerged; the downflow of the water through the small pipe draws with it the air contained in the elbow of the syphon, and the latter begins to work until, the discharge having reduced the water to the prescribed level, air is readmitted to the bend of the syphon and its operation stopped. So long as the depth of water over the head of the feeder is less than 2 in., the whirlpool formed by the pressure of the atmosphere at the orifice causes the syphon to draw air as well as water, and therefore to discharge with reduced volume; as soon, however, as the water has risen to 2 in. above the head the syphon works full bore, and discharges at the rate of 1500 gallons per second.

The apparatus is therefore self-regulating as well as self-acting.

The system claims, and appears to possess, the advantages of being simple in construction, certain in operation, and not liable to get out of repair.

The feed apparatus, which is the only novelty, is the idea of M. Hirsch.

The principal public buildings and restorations executed in Paris during the last twelve years are recorded in an atlas of plans exhibited by the department des Travaux Publics. The extent of these works may be gathered from their cost, 6,680,180*l.* The designing of these works shows not only great skill expended upon the construction itself, but a skilful adaptation of site and judicious utilisation of ugly waste spaces have also contributed to the general embellishment of the capital. It will be remarked that in the designing of hospitals and lunatic asylums great care has been taken to obtain a cheerful look-out from the ward windows. In the arrangement of the public abattoirs the approaches from the railway stations have been studied so as to give the least amount of street through which cattle are driven, whilst the disposal of the dead meat is made as easy as possible. None of these details have been left to take their chance.

The next work selected for notice—an undertaking being carried on, not upon French territory, but the credit of which is due to France—is, perhaps, the most interesting object of civil engineering at present in progress in the world—viz., the cutting the maritime canal through the Isthmus of Suez; models, plans, photographs, and a panorama of which are exhibited in a detached building in the park, constructed in the style of an Egyptian temple. No one exhibit has attracted more of the attention of the visitors to the Champ de Mars than have these models, and none has better repaid the trouble of examination. The works which they illustrate deserve attention alike from their great magnitude and importance from an engineering point of view and from the greatness of the beneficial influence which their completion is likely to exercise upon the commerce of the world.

The idea of this great work, by which we hope the whole civilised world is shortly to be benefited, is due to M. le Baron Lesseps, who has long interested himself with the affairs of Egypt, having filled an important diplomatic post for many years in that country. The execution of the scheme is due to French engineering skill, and the principal part of the capital has been subscribed in France.

The works are illustrated by a model of the isthmus on a scale of $\frac{1}{100000}$ th; the heights are comparatively exaggerated, 60 to 1; the width of the canal, 6 to 1.

The Isthmus of Suez, at the part selected for the operations of M. Lesseps, is about seventy-two miles wide, measured as the crow flies, from Pelousa, on the Mediterranean, to Suez, on the Red Sea. The levels of these two seas is not far from identical, the mean level of the Red Sea being but $\frac{6}{10}$ in. higher than that of the Mediterranean. The general character of the isthmus between Pelousa and Suez is flat, and is the natural water-basin of the adjoining countries, which slope gradually towards the isthmus, east and west, from Asia and Africa. Starting from Pelousa, and following, southwards, the line traced out for the canal towards Damietta, we come to the lagunes of Menzaleh, about twenty-five miles long, separated from the Mediterranean by a strip of beach, which runs out shoal for a considerable distance into the sea. The Mediterranean mouth of the canal is cut through this strip; and here, situated eighteen miles west of Pelousa, is Port Said, created by the company to be their base of operations, and where are established considerable workshops for the maintenance and repair of plant.

Formerly these desolate lagunes of Menzaleh were vast cultivated plains, which fertilised by the Tanitique branch of the Nile, supported a considerable population, and grew a large quantity of the corn which supplied the granaries of ancient Rome.

After leaving the lagunes, the line of the canal cuts through a strip of sand about four miles wide, elevated about 4 ft. above the sea; this strip separates the lagunes of Menzaleh from those of Ballah, the width of which is fourteen miles. Then occurs the elevated plateau of El Guisar, the highest ground between Pelousa and Suez; through this the canal is carried in a very considerable cutting, nine miles and a half long, with a maximum depth of 55 ft. After crossing this plateau a depressed plain is reached called Lake Timsah; the lowest level of this plain is 19 ft. below the water of the Mediterranean. On the borders of Lake Timsah, or Lake of the Crocodiles, is Ismailia, a town

built by the company midway between the Mediterranean and Red Sea, where they have located the general direction of the works. The line then crosses a second elevated plateau, called Serapeum, 46 ft. above the level of the Mediterranean, and nine miles long. South of this lie the lakes of Amer, two shallow lagunes separated by a narrow strip of sand; the exact line which the canal will follow through Lake Timsah and Amer has not yet been decided upon. This part of the canal will be left until the rest of the line is completed. Meantime, water communication across them is obtained by admitting the water of the Mediterranean into Timsah, and the Red Sea into Amer, thus transforming them into navigable inland seas. Beyond the lakes of Amer is the raised ridge of Chalouf, 26 ft. above the level of the sea, the southern slope of which forms the plain of Suez, elevated 6 ft. 6 in. above the sea level. After crossing this plain, the lagune of Suez is reached, which communicates by a shallow inlet with the Red Sea.

Thus the total length of the canal is about 100 miles, of which thirty-seven miles is in cutting, whilst sixty-three miles are at or beneath sea level.

The first work undertaken by the company, preliminary to their main work, was the extension, as far as Lake Timsah, of the old fresh-water canal, which, starting from Moëa, wound eastward, past Abassieh to Ras-el-Ouady. This extension gave them means of transport for their provisions and materials from the Nile into the very heart of the isthmus, a supply of water for their workmen and for their engines, and enabled them to establish their central dépôt of Ismailia. Southwards from Ismailia the fresh-water canal was continued nearly parallel to the intended line of the maritime canal as far as Suez, and northwards the water was led in pipes from a reservoir at Ismailia as far as Port Said, following the line of the works. The original source of supply of the freshwater canal from Moëa was supplemented by a cut from the Nile at Boulak to Abassieh, forty-four miles long; the cross section of the freshwater canal is 56 ft. at water level, 26 ft. at bottom, 6 ft. 6 in. deep.

The general dimensions of the maritime canal are: width at water level in embankment, 328 ft.; ditto in cutting, 190 ft.; width at bottom, 72 ft.; depth, 26 ft. 3 in.; the batter of the sides varies with the nature of the soil, the steepest slope being about $2\frac{1}{2}$ to 1.

The sectional form of the canal has been the subject of anxious consideration. It was originally intended to make it somewhat narrower than the above dimensions, and steeper at the sides; but it was found that at or near the water's edge a slope as steep as 2 to 1 was subject to degradation from the wash of passing vessels; the general batter from about 4 ft. below water level to the bottom is now intended to be from $2\frac{1}{2}$ to 1 to $3\frac{1}{2}$ to 1, whilst the edge is considerably flattened so as to approximate to the shelving form which sand assumes when acted upon by the wave from passing vessels.

The first work of digging through the strip of head separating the Mediterranean from the lagune of Menzaleh was performed by fellahs supplied by the Egyptian Government; the mode of operation was the old one of scooping the sand and carrying it in baskets on the head. The work of the fellahs was confined to the higher and drier parts of the excavations, the lower part being performed by means of steam dredgers, twenty of which were put in operation by the company; these dredgers were driven by 15 horse power engines, lifting twenty-six gallon buckets at the rate of twenty per minute. The sand dredged north of the beach was deposited to form the platform upon which Port Said was subsequently built; the sand excavated on the south side was placed so as to form the canal banks, *en cavalier*, through the lagunes. By these banks the waters of the canal were isolated from those of the lagunes, guarding at once against sudden variations of water level arising from storm, and protecting the bed of the canal from being silted up by sand blown across from the plains. A good illustration of the works in the great cutting of El Guisr, as carried on by fellahs, is given in the drawing which hangs on the wall on the right on entering. When this cutting was about half accomplished, the supply of fellah labour by the Egyptian Government was stopped; the primitive baskets of sand carried on human shoulders disappeared from the scene, and were replaced, by MM. Borel and Lavally and M. Couvreux, contractors, with steam instead of human power.

M. Couvreux contracted for the enlargement to its full destined width and depth of the cutting of El Guisr. Messrs. Borel, Lavally, and Co. undertook the remainder of the work. The modes of carrying out the works adopted by Messrs. Borel and Lavally are shown in the great model in the centre of the room. The model on the left bank of the canal shows the mode of disposing of the sand dredged from the bed of the canal—by tipping the dredge-buckets direct into a long shoot which leads inshore from the top of the dredge-frame. This shoot is inclined towards the shore at a gradient sufficiently quick to enable the silt charged with water to flow along it. The discharge is assisted by pumping water into the dredge end of the shoot by means of two rotatory pumps worked by the engine of the dredger, supplemented, in case the nature of the silt requires further liquefaction, by a second pump placed upon the barge, and worked by a portable steam-engine. The descent of the silt is further helped by scrapers, fitting the concave surface of the shoot, attached to endless chains passing over pulleys fixed at each end of the shoot. These scrapers are also driven by the dredger-engine. These shoots are 280 ft. long; their section is a semi-ellipse, 5 ft. wide and 2 ft.

deep. They rest upon a pair of lattice girders, which latter are carried by an upright iron framing, standing upon a barge moored inshore of, and parallel to, the dredger. Lateral and vertical play is allowed for in the attachment of the shoot to the top of the frame of the dredger, and to the frame carried by the barge. The dredger-engine is a direct-acting, double-cylinder condensing-engine of 85 horse power (nominal). The gradient of the shoot is varied to suit the description of the silt dredged. To discharge fine sand, a fall of 1 in 20 is sufficiently steep, but the pumps have to supply a volume of water equal to half the sand; with clay, a fall of 1 in 12 is necessary, but less water suffices. The mode of disposal above described is the most expeditious and economical in use on the works; it is applied in all cases where the height of the bank is not too great. Each dredger and shoot is calculated to dispose of about 1200 cubic yards per day.

Where the banks are too high to be commanded by the shoot, another apparatus is used—the “*appareil élévateur*,” a model of which is shown upon the left bank of the canal. This apparatus is designed to lift trucks full of sand from barges and run them to tip inshore; it consists of two parallel lattice girders, extending from a barge moored to the shore, in a direction parallel to the canal, carrying upon their upper edges a tramway, which rises shorewards at a gradient of about 1 in 6; the lower end of these girders is about 10 ft. above the level of the water, the shore or higher end 46 ft. This frame is supported at two points, about 14 ft. apart—viz., one on a barge moored close alongshore, the other on a platform-carriage on the shore. Sufficient preponderance is given to the canal end to support the shore end, together with the weight of a full wagon. Very considerable ingenuity is exhibited in the arrangement of the framing, and in its attachment at its points of support, so as to render it sufficiently flexible to be non-susceptible of injury from the rolling of the barge, whilst its strength is sufficient to carry the weight of the full trucks running over it. On the tramway runs a carriage, consisting of two pairs of flange wheels and axles, kept about 4 ft. apart by means of two horizontal pieces resembling the fiddle-sticks of a tip wagon; the wheels are keyed to the hinder axle; they run loose on the fore axle. To this carriage is slung the sand-truck, and it is the vehicle by which the latter is carried inshore. The fore axle of the platform-carriage is thickened between the wheels, so as to form two drums of different diameters; to the lesser of these is attached a rope, which lifts the sand-trucks from the barge, and to the larger a second rope is attached, which passes over a pulley-wheel at the shore end of the tramway, and which draws the full wagons up the incline from the barge. The working is as follows: The sand, which has been shot by the steam-dredger into boxes resembling ordinary end-tip wagons, containing about three yards cube, is carried by a barge to the lower extremity of the elevator; a tackle attached to the small drum above described is hooked on to rings in the side of the wagon; the wagon, thus slung to the platform carriage, is hoisted by the engine to a height sufficient to allow of two small truck-wheels, which are attached to the hinder end of the wagon, being engaged in the metals of a second tramroad placed below, and for five-sixths of its length parallel to the first. The engine, by pulling over the pulley-wheels, drags the carriage up the incline to the shore end of the elevator. The discharge of the contents of the sand-wagon is managed in the following way: As has been already stated, the upper and lower tramways are laid parallel to each other throughout about five-sixths of their lengths. At the shore end, however, they converge, the gradient of the lower tramway, on which run the small truck wheels of the sand wagon, being considerably steepened; the hinder part of the wagon is thus borne up, whilst the forward or tip end is thrown down, so that the catch of the tailboard being disengaged the contents are shot. The empty truck then runs down the incline, is lowered into the barge, and a full one picked up. There are at present eighteen of these elevators at work; each of them takes two of the large dredgers to feed it.

M. Couvreux has employed an apparatus termed a dry dredger in the enlargement and deepening of the great cutting of El Guisr. The apparatus consists of a platform-carriage 20 ft. long by 10 ft. wide, mounted upon nine wheels, running on a three-rail tramway. On this is a steam-engine driving a chain of dredge-buckets, which mount a jib projecting perpendicularly from the platform-carriage, and which tip their contents into sets of earth-wagons which run upon a second tramway parallel to the first. The trains of sand-wagons are then run to tip by a locomotive. Each of the dry-dredgers shift about 900 yards cube per day of loose fine sand. The soil met with in the line of excavation for the canal is chiefly sand, river mud, and clay. A vein of rock crossing the ridge of Chalouf, about 3 ft. above the canal bed, is the only excavation which requires blasting.

A very considerable work in connexion with the undertaking of M. Lesseps has been the construction of Port Saïd, the Mediterranean harbour of the canal. This port is formed by two breakwaters running out a considerable distance into the sea, their shore ends being 4592 ft. and their sea ends 2296 ft. apart. The west breakwater is 10,168 ft. in length, the east 5000 ft. Their upper surface is 17 ft. wide; their sides batter 1 to 1 to the base. The harbour enclosed by these breakwaters is being dredged out to a uniform depth of 30 ft. The material used in their construction is concrete, blocks composed of sand and ground

lime of Thiel (from Ardèche, in France), the proportions being one of lime to four and a half of sand. The works of Port Saïd are being carried out by MM. Dussand, who have already constructed, with the same material, breakwaters at Marseilles, Cherbourg, and Alger. MM. Borel and Lavally have guaranteed the completion of their works on October 1, 1869.

The great work, of which the above is a very brief and imperfect sketch, will well repay an attentive study. There is no country so directly interested in its success as is England, the mistress of India. Hitherto it has been the fashion to consign the Suez Canal to the limbo of great impracticable schemes; we venture to think that amongst the many doubting Englishmen who have visited the models in the Paris Exhibition, and have been induced to inform themselves of what has been done and is doing, there are not a few who will have their scepticism in the feasibility of the scheme somewhat shaken.

America exhibits but few specimens of her engineering skill, and respecting those few it was by no means easy to obtain much detailed information.

A bold engineering scheme for the supply of water to the city of Chicago, in Illinois, is recorded upon a plan hanging against the west wall in the United States section, numbered 7 in general catalogue.

Chicago, the capital of Illinois, is situated upon the great lake of Michigan, whence it derives its supply of water.

The pollution of the water near the shore proceeding from the discharge of the town drains, &c., rendered it necessary that the supply for the use of the town should be drawn from a considerable distance out in the lake, and with this view a shaft, consisting of cast-iron pipes, 9 ft. diameter and $2\frac{1}{2}$ in. thick (in seven lengths of 9 ft. each), was sunk from the surface of the water, two miles from the shore, to about 35 ft. beneath the bed of the lake. The depth of the lake is here about 28 ft.

The part of this pipe which extends from beneath the level of the bed of the lake to its greatest depth is cased with brick-work in cement. The part of the pipe which stands in the water is protected from the action of the waves by a breakwater built round it in the form of a pentagon. This breakwater is a strong wooden framing, filled in with coarse concrete or rubble masonry. From the lower extremity of this shaft, 63 ft. below the surface of the lake, a circular tunnel, lined with brickwork, in cement, and 5 ft. diameter in the clear, and two miles in length, is driven beneath the bed of the lake towards the town, where it meets a second vertical shaft sunk within the shore line. This latter communicates through a chamber containing five wrought-iron regulating sluice-gates, with a reservoir from which, by means of a large pair of pumping-engines driven by steam power, the water is lifted to a water-tower 120 ft. high, and distributed all over the town. A legend on the plan states that the work is the design of Mr. Coote, and that it has been three years in construction.

A good example of the ingenious application of wood to bridge construction, for which America is famous, will be found in a model $\frac{1}{4}$ th full size of a wooden railway swing-bridge which has recently been constructed in the State of Ohio. Timber bridges are especially suited to a new country where timber is cheap, and where it has been necessary to open up a new country rapidly and economically. These structures are, however, to be considered as essentially temporary in their character, and are generally built with a view to their being replaced at some future time in some more durable material. The bridge exhibited here is of a larger span than usual in designs of this class. Each opening has a clear span of 150 ft.; the diameter of turntable is 30 ft.; length of bridge over all, 835 ft.; the depth of the truss is 10 ft. at the ends, 34 ft. at the centre. The arched part is composed of four timbers, 10 in. by 6 $\frac{1}{2}$ in.; main struts, 14 in. by 8 in., extend to each side from the turntable to give support to the arched top, which is further strengthened by three straining pieces 8 in. by 10 in. The chord consists of four 12 in. by 6 $\frac{1}{2}$ in. timbers, and is put together with a camber of about 6 in. The weight of the bridge is 200 tons.

Within the space to which it is necessary to restrict this memorandum it has been impossible to do more than briefly to call attention to a few of the most noteworthy exhibits. It will be seen that, though the progress of civil engineering has not been fully represented, no country having put forth its full strength but France, there is still much exhibited that is interesting and instructive.

PHILOSOPHICAL INSTRUMENTS AND APPARATUS FOR TEACHING SCIENCE.*

PARIS EXHIBITION.—CLASS 12.

By C. R. WELD, Esq.

ALTHOUGH not calculated to arrest the attention of the majority of visitors to the Paris Exhibition, the philosophical instruments and apparatus for teaching science take high rank among the vast variety of objects amassed in the Champ de Mars. For it is by means of instruments like these that Nature has revealed many of her most important secrets to man. Viewed in this light, an examination of the philosophical instruments in this remarkable exhibition cannot fail to be deeply interesting and at the same time instructive.

Surveying Instruments.

The show of these important instruments in the Paris Exhibition is greatly superior to that in the International Ex-

* We publish from this report such extracts as are most interesting to our readers.

hibition of 1862; for, though not presenting any great novelty of construction, their workmanship is better, and, with few exceptions, they display greater perfection and a much higher finish. This is especially remarkable with respect to a theodolite, constructed by G. Brauer, Russia (16), under the direction of Professor Jacobi, of St. Petersburg. This instrument, which was tested by the jurors, was found to be wonderfully accurate, and to answer all its requirements admirably. F. Drier and Co., France (25), exhibit several beautiful surveying instruments, many of which were used in the survey of Paris. They highly merit the closest examination. The levelling instruments shown by Gravet-Tavernier and Rigaud, France (23 and 94), are excellent. The latter exhibits a theodolite made of platinum. The instruments of this description exhibited by J. Kern, Switzerland (10), have long enjoyed high reputation. Several will be found in the Paris Exhibition, remarkable for their precision and very moderate price. The principal novelty they display is in their mechanical arrangements, though, in the opinion of some of the jurors, rigidity has been somewhat sacrificed in the endeavour to obtain lightness. The establishment of M. Kern at Aarau employs 120 workmen in the manufacture of surveying and mathematical instruments, large quantities of which are exported to England. The theodolites exhibited by Pistor and Martins, of Berlin, Prussia (6), are of the highest order of excellence, and are remarkable for a very ingenious apparatus for reversing the telescope in its bearings. The Société pour la Construction d'Instruments de Physique de Genève, Switzerland (12), also exhibit good surveying instruments, very remarkable for their moderate price. The Industrial Institution of Lisbon, Portugal (2), exhibits well-constructed theodolites, showing a great advance in excellence of workmanship over those exhibited by the same institution in 1862. Cavaliere Rossi, of Rome, well known for his admirable survey of the catacombs under that city, exhibits a stenographic and orthographic machine, which has been used with great success in this subterranean survey. "The machine is carried in the hand. A long micrometer screw has a pulley at one end; over this pulley is wound an endless cord of definite length, as, say, one yard. The operator, placing himself close to the wall to be surveyed, measures off yard by yard with his cord. The act of doing so turns the screw at each yard, a definite quantity, of which the proportion to the yard is known. The screw moves a tracer over a piece of paper fixed horizontally on the machine. The tracer has two points, which can be separated by a quantity representing the width of the path or gallery being surveyed. The vertical section is obtained by analogous means, a light being carried in advance of the observer on which to direct a pair of sights, the inclination of which determines the position of another tracer on a second piece of paper attached to the machine." Such an instrument cannot, of course, give very accurate results; but with it Cavaliere Rossi has made a very interesting survey of the catacombs.

H. Schaeffer, Grand Duchy of Hesse (2), exhibits several good theodolites and levels. The workmanship of these instruments is of a superior order, and reflects great credit on the establishment from which it emanates. Becker and Buddingh, Holland (7), also exhibit some well-constructed levels of good quality.

Under the head of surveying instruments may be included planimeters and telemeters, several varieties of which will be found in the French department of philosophical instruments. Planimeters, which, it may be remarked, are more used on the Continent than in our country, are constructed for ascertaining, without entering into trigonometrical calculations, the area embraced within any given outline traced on a plane surface. "The instrument acts on the principle of mechanical integration—that is, the summing up the small areas into which any given figure may be supposed to be divided by an indefinite number of equidistant lines, either parallel to each other or, on passing through the same point, the former indicating in geometrical language rectangular and the latter polar co-ordinates. It will be easily understood that, if motion can be communicated to a rotating wheel, which is jointly proportional to the number of successive lengths of the elementary portions into which the surface is supposed to be divided, the aggregate motion of the wheel multiplied by some known constant will represent the superficial area to be determined."

Telemeters, or, as the name implies, distance-measurers, consist of two telescopes placed at the ends of a short base, composed of two concentric tubes containing reflecting prisms, by which the object is bisected horizontally and the images of the upper and lower halves brought before the eyes of the observer. A coincidence can be obtained by moving one of the prisms attached to a long graduated arm, the reading of which gives, by reference to a table, the required distance of the object. Specimens of both these instruments are exhibited by Gravet-Tavernier and I. Lefebvre, France (23 and 42).

Dividing-Engines.

Several of these instruments may be seen in the present Exhibition. Among the best are those of L. Perraux, France (31), who exhibits circular and straight line dividing-engines of various sizes, and, as far as they could be tested, of very great accuracy. C. A. Guillemot, France (40), also shows a dividing-engine of a novel construction, provided with an arrangement by means of which a curve exhibiting its own error can be described. The above makers also display some very delicate cathetometers, by which the distance between two points in a vertical line

can be determined to $\frac{1}{1000}$ of a millimetre (.0002 English inch). Two cathetometers, exhibited by G. Brauer, Russia (16), made under the direction of Professor Jacobi, also merit examination. The smaller one is exquisitely finished, and is capable of measuring distances between two points with very great precision.

It is absolutely essential in the construction of these delicate instruments that the working parts should be free from tremor. This condition has been attained in the above instruments, which are decidedly the best cathetometers that have ever been exhibited.

Pantographs.

Several pantographs, embracing in some instances new constructions, are exhibited; but the only instrument of this kind which merits special notice is that exhibited by A. Gavard, France (33). This instrument, consisting of a series of brass rods jointed together in the form of a parallelogram, so as to have perfectly free motion in a horizontal plane, is made by very ingenious and novel contrivances to produce duplicate reductions of figures, &c., not only on plain surfaces but on cylinders. By its means patterns may be drawn and engraved on copper rollers with the greatest precision, and impressions taken from them. The invention, which is highly creditable to M. Gavard, is likely to be of great benefit to the calico-printing trade.

Under the head of pantographs may be included a microscopic writing-machine, exhibited by E. Hardy, France (91), but which falls far short in its performance of Mr. Peter's celebrated machine exhibited in 1862, with which the entire Bible may be written three times in the space of a square inch.

Calculating-Machines.

Under this head, the present Exhibition shows no advance over that of 1862, the few calculating-machines exhibited being of a very elementary nature. These instruments are essentially of two kinds. In the simpler form the operation of addition is effected by causing a figured wheel to advance a given number of unit spaces, by moving through the same number of spaces a wheel with which it is in gear. The process of multiplication is merely that of successive additions, and subtraction and division are the inverse processes of the former. The celebrated Pascal constructed a machine for executing the ordinary operations of arithmetic; and Leibnitz invented another by which arithmetical computations might be made. The only calculating-machine in the Paris Exhibition worthy of notice is that exhibited by C. X. Thomas, France (29). This machine multiplies eight figures by eight in eighteen seconds, divides sixteen figures by eight in twenty-four seconds, and extracts the square root of sixteen figures in ninety seconds. The price of the instrument is 20*l*. It is to be regretted that a specimen of one of the extremely ingenious and beautiful calculating-machines of Messrs. Scheutz, of Stockholm, is not in the Paris Exhibition. One of these machines is in the office of the Registrar-General in London, where it is performing very useful work. It not only calculates to sixteen place of figures, but simultaneously prints the results. Specimens of the printing executed by this machine may be seen in the Swedish department of the Exhibition.

Electrical Machines.

The most important philosophical instruments connected with electricity are those by which the various measurements of electrical quantities are effected. These are divided into strength of currents, quantity of electricity, electro-motive force and resistance of conductors. The most interesting electrical machine in the present Exhibition is that exhibited by M. Wesselhoft, Russia (14). It is the invention of Professor Töpler, of Riga, and acts on the principle of multiplying induction resulting from a series of glass plates rotating with great rapidity. This instrument is especially deserving of examination, and is a great improvement on Holtz's apparatus of a similar nature.

Few philosophical instruments possess greater interest than those known as electro-magnetic. From the period when Oersted, in 1820, linked the sciences of electricity and magnetism together, and proved that the one acts upon the other, not in straight lines, as other forces do, but in a direction at right angles, so that, by ultimately making and destroying the action of magnetism, a moving power can be obtained capable of mechanical application, great expectations have been entertained that these forces would admit of useful practical application. But hitherto no electro-magnetic machine has been constructed at all capable of competing successfully with the steam-engine. P. Dumoulin-Froment, France (83), exhibits a machine of this kind, but it is more in the nature of a toy than a machine of practical utility. But Oersted's discovery of these electro-magnetic laws have been turned to signal advantage for astronomical purposes. The Americans were among the first to apply these in the determination of the difference of longitude, and W. Bond and Son, United States (4), exhibit an astronomical clock and chronograph which was used for ascertaining, in connexion with the Atlantic cable, the difference of longitude between Newfoundland and Valentia. France exhibits some grand magneto-electrical apparatus. That of Nollet's, exhibited by Ruhmkorff, France (1), constructed for the Ecole Polytechnique, and his inductive apparatus for converting dynamic into static electricity, are especially worthy of being attentively examined.

General Morin (not in the catalogue) exhibits a very ingenious apparatus for registering minute variations of temperature by means of a thermo-electric pile. The apparatus is composed of fifteen brass rods and the same number of iron ones, so disposed as to constitute a thermo-electric pile

of fifteen couples. If we suppose one of the soldered points of junction of the two metals to be kept at a constant temperature—the freezing point, for instance,—then, another junction being situated in a given medium at another temperature, a current will be excited in proportion to the difference. The existence of this current is made apparent by the deviation of a magnetic needle, the electric fluid previously passing through the bobbins of a common multiplier. The needle itself is suspended by a silken thread. Let us now suppose the needle to be situated in the plane of the magnetic meridian, and to be provided with a vertical shaft proceeding from its centre and supporting a copper needle at its lower end. As copper is non-magnetic, it cannot exercise any influence on the desired result; and being parallel to the iron needle, and consequently in the same vertical plane with it, it will strictly indicate the same deviations. A horizontal disc of white paper situated under this copper needle, and supported by a vertical shaft made to revolve by clock-work, completes its entire revolution in the course of one hour, being, in fact, neither more nor less than a dial-plate, which, instead of being fixed and provided with movable hands, as in a common watch, or rather chronometer, is itself movable round a fixed hand which is represented by the copper needle. The latter has a sharp vertical needle point fixed at its lower surface. At the expiration of every quarter of an hour the paper disc suddenly springs upwards, meets the sharp point, and is pricked by it. This mark will show what was the position of the needle at a given hour; and as this position marks the degree of the intensity of the current, which is itself but an exponent of the temperature of the medium under consideration, it follows that by this contrivance the variation of temperature which has taken place in the course of one quarter of an hour is registered. It will, of course, be understood that the paper disc returns to its ordinary level as soon as it has received the mark of the needle. The performance of this novel and ingenious apparatus is stated to be highly satisfactory.

W. Ladd, United Kingdom (not in catalogue), shows a very ingenious electro-magnetic machine, with a new application of the principle of augmenting indefinitely the power of an electro-magnet by currents produced by itself. The apparatus can be used for lighthouse and other purposes, and is driven by a one-horse power steam-engine, by which force effects are produced equal to a fifty Grove's battery.

It may not be out of place to state here that electricity is likely to receive many new and important applications in the arts, one of which is the refining of sugar. While, by means of an electro-magnetic machine, a current of electricity may be made to produce its equivalent of mechanical power, so, by a reverse process, mechanical power may be made to produce electricity. It has been found by experiments that a stream of electricity derived from a powerful electro-magnetic machine driven through a solution of brown unrefined sugar will bleach it, electricity being thus made to perform the function of charcoal. It appears that one of Wilde's electro-magnetic machines, driven by a 15-horse power engine, has been set up for this object in a sugar-refinery in Whitechapel.

Under the head of electricity may be included chronoscopes and chronographs. These instruments are chiefly applied to the measurement of the velocity of projectiles by electricity, and for registering the exact moment at which an astronomical or other observation is made. The chronoscopes shown by E. Hardy, France (91), constructed for the French Government, are the best instruments of the kind in the Exhibition.

The instruments used for the automatic regulation of the carbon electrodes of electric lamps are extremely interesting. England is not represented in this department as she was in 1862; but France, in the exhibition of V. Serrin's (41) extremely beautiful and ingenious apparatus, now used in many of the French lighthouses, is admirably represented. The apparatus has been greatly improved since 1862, and the automatic regulation of the charcoal points is now under the most perfect control. The intense nature of this light is such that it has been used with great success in obtaining photographs of the catacombs under Paris, and of the sewers, specimens of which may be seen adjoining M. Serrin's exhibition.

J. Kravogl, Austria (6), exhibits the model of an electro-magnetic machine, combining some new principles; and, although not included in the catalogue, it may be desirable to state that our War Office has sent to the Exhibition Mr. Wheatstone's ingenious magneto-electric apparatus for firing guns.

An apparatus for engraving by means of electricity, exhibited in the machinery department of the Exhibition, though not included in the class of philosophical instruments, may be incidentally noticed. It is extremely ingenious, and illustrates, in a very forcible manner, the great activity of mind now devoted to utilising electricity.

The applications of electricity to telegraphy are abundantly illustrated in the Paris Exhibition, but the examples appertain to another class (64), and that of electricity to clocks to class 23.

Elliott Brothers, United Kingdom (13), exhibit Sir W. Thomson's astatic reflecting galvanometer used in laying the Atlantic telegraph cable; and P. H. Desvignes, United Kingdom, (11), a gyroscope which revolves by electro-magnetism.

There is a fine exhibition of glass tubes for showing electricity *in vacuo* and in various highly rarefied gases. Those exhibited by C. H. Seguy and Ruhmkorff, France (38 and 1), and by H. Geissler, Prussia (1), are the most interesting.

G. Trouvé, France (8), exhibits various ingenious automatic toys, such as humming-birds, small gyroscopes, heads of animals, &c., set as pins, which move by magneto-electricity.

SUSPENSION BRIDGE OVER THE RIVER OHIO AT CINCINNATI. (1057 FT. SPAN).

MR. JOHN A. ROEBLING, ENGINEER.

(For Description see Page 335.)



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ENGINEERING.

FRIDAY, OCTOBER 11, 1867.

STEEL-LAID RAILWAYS.

A LINE of railway laid in steel is now well known to be superior, in respect of economy of working, to one laid in iron. It is well known to require less labour in keeping up, and, all other things being equal, to maintain a better running condition than an iron way. The reasons of its superiority are apparent enough, and it is only to be regretted that experiments have not been made under conditions to give exact data on this point, instead of merely general, although very favourable, indications. A yielding roadway is a bad roadway for traction; and while bad at all speeds, it is especially bad at high speeds. Even if the old fish-bellied rails could now be used without actually breaking, their yielding, at every chair, would prevent the attainment of anything like really high speed, except with great danger and with a great expenditure of power. Ordinary parallel iron rails yield less than fish-bellied rails, and steel yields still less than iron. The precise conditions under which a yielding rail causes increased resistance to traction, especially at high speeds, require perhaps nice investigation; for, speaking generally, it may be maintained that the onward motion generated by the gravity of the load in rolling from one end to the mid span of a moderately elastic bar, supported at both ends, exactly corresponds to the resistance due to gravity in rising again from the mid span to the other end. A rolling weight placed near one end of a moderately flexible bar will roll, of itself, to or beyond the mid span, and bend the bar to the extent due to its own elasticity and to the load. The work thus done by gravity is exactly equal to that required to take the load from the mid span up to the other end of the bar, and were there no resistance to rolling, per se, the weight would traverse from one end of the bar to the other, and back again, *ad infinitum*, merely as the result of gravity acting upon a flexible rail. But these motions, recurring in definite spaces of time, cease at each end of the span, whereas, in the case of a railway train, the wheels, rising rapidly from the successive hollows, acquire an upward direction beyond the next chair, and fall with increased force upon the rail beyond. When we say "fall," we do not mean that the wheels are really carried clear off the rails at any moment, but merely that their pressure, as due to the weight upon them, is momentarily lessened, and again momentarily increased, when the upward motion in rising over the sleeper is exhausted. Whatever may be the explanation (and our few observations above are intended to provoke no controversy, nor, least of all, to advance any new theory of our own), we have the following well-established facts: The axle friction of carriages, and the mere resistance to rolling along a smooth rail,

are constant at all speeds. The actual resistances to the motion of trains, upon our best railways, are, however, considerably greater at high than at low speeds, and the excess is very much beyond that known to be due merely to the atmosphere. Besides the latter resistance, there is a considerable resistance known to increase in the ratio of the square of the speed, and it is, we believe, the universal custom of the profession to speak of this as the resistance due to "concussions," and what but an irregular, uneven, or yielding line can cause concussions? Mr. D. K. Clark's experiments, very closely confirmed by a series made by ourselves, up to speeds of 59 miles an hour, on the London and North-Western Railway (see ENGINEERING, vol. i., p. 168), show the variable, as distinct from the constant, resistances to amount to 2.34 lb. per ton at 20 miles an hour, 9.36 lb. at 40 miles an hour, and 21.05 lb. at 60 miles an hour, varying as the square of the speed in miles per hour divided by the constant 171. These increased resistances apply to lines in good and even first-rate condition, and are much greater on lines not well kept up. The constant resistances are, meanwhile, but from 8 lb. to 10 lb. per ton for the engine, tender, and train, so that the resistances due to "concussions" are about equal to the constant resistances at 40 miles an hour, and twice as great at 60 miles an hour.

At the high and increasing speed at which railways are now worked, these "concussions," due to the irregularities of our lines, thus absorb the principal portion of our locomotive power, and entail a heavy charge in the shape of working expenses. But for these "concussions" our lines might be worked, probably, at 35 per cent. instead of 50 per cent. of their present gross receipts, there being always a considerable proportion of the working charges which, like management, station attendance, &c., are independent of the condition of the line.

Although we have no precise experimental data—and it is greatly to be regretted that we have not—to show the superior working condition of a steel-laid as compared with an iron-laid line, it is notorious and beyond dispute that the steel lines are worked at less expense, not only so far as renewals of rails are concerned, but in respect also of maintenance of way, locomotive power, and wear and tear of carriage and wagon stock. Steel rails, by their superior hardness, strength, and stiffness, approach much nearer than iron to the mathematical planes to which all rails should conform, in order to diminish the resistance to traction to a minimum. Taking the working expenses of railways at their present average rate, it would be a low estimate indeed to say that, even apart from all consideration of the renewals of rails, the superiority of steel over iron rails does not amount to at least 2d. per train mile, taking into account the saving of locomotive power, wear of carriage and wagon stock, maintenance of way, &c. At this rate a line, having fifty trains each way daily, and having 240 tons of steel per mile of double line, would save, yearly, 304l. per mile of way, equal to more than 25s. per ton of the steel in the line. One great objection heretofore made to the introduction of steel has been the extent to which the compound interest upon its increased cost would mount up in a series of years; but even if the saving in working expenses were but half that estimated above, it would fully pay for the whole interest of steel, at 12l. 10s. per ton, at which rate steel rails are now often sold. Under the hardest wear, steel rails have outworn twenty-five times their weight of iron (see ENGINEERING, vol. iii., p. 221), and no estimate now made of their service is ever less than that of a threefold durability over iron; but if their durability was only as much greater than that of iron as their cost is greater, or even if it were absolutely no greater, it is virtually certain that they would prove cheaper in use than iron, because of the superiority of working condition of a steel-laid as compared with an iron-laid line, and the consequent very considerable saving in working expenses.

WORK TO BE DONE.

THE public works of the kingdom, as executed by our own profession, represent an investment exceeding the national debt, or more than 800,000,000l. More than half of this has gone into railways alone, works which, hardly twenty-five years ago, engaged but little attention from capitalists, but of which the gross earnings are now nearly forty millions yearly, capable, under proper management, of paying a reasonably good dividend upon their total cost. As much may be said of our extensive system of canals, artificial harbours, docks and piers, waterworks, gas-works, drainage-works, steam-shipping, our thousands of

road-bridges, and other investments in engineering works which make up the tremendous total already quoted. Even this has not been enough to employ our capital, and we have sent millions abroad—to India, to America, indeed to almost everywhere—investing not only in foreign works, but lending also to foreign governments almost anything they chose to ask for. Some of these works have been shamefully mismanaged, and the success, often great, of others has led to the maddest speculation in further works designed "for the future," and that vague yet expressive term has thus become the aversion of capitalists, who, waiting only to find new channels of investment which will pay now, lock up their money in the belief that none exist. And it is to capital alone that engineers can look for employment—the capital which yet waits to be reassured after the bitter lessons of the Overend-Gurney collapse, the Chatham and Dover, North British, Great Eastern, and Brighton revelations, the Leeds and Birmingham bank failures, and those of half-a-dozen other banks in London, the Atlantic and Great Western miscarriage, and the thousand instances of joint-stock disaster variously brought about by miscalculation, imprudence, and downright dishonesty.

And yet our export trade, and all trade not due to speculative undertakings, is as good as ever, and the railways are earning more money than ever before. It is certain, too, that such things as commercial honour and commercial judgment still exist, that there are still sound, safe engineers who will not lend themselves to company-mongering and to the interests of speculation, and that only discrimination and honesty are necessary to discover fresh work to be done, and which will pay reasonably well upon the capital required for its execution.

It has long been evident that railways can compete successfully with water carriage in the transport of coal, and more than one-half of the six million tons now brought to London yearly comes by rail, notwithstanding the competition of the steam colliers. It has become a matter of necessity that we should now have a great direct coal line from South Wales to London, and this undertaking cannot be much longer delayed. In Wales we have the very best coal in the kingdom, needing only cheaper and more direct conveyance to render it the chief steam coal in the factories of London. We equally need a great and independent line from South Staffordshire to London—a line often urged and promoted by the ironmasters of the district, and which should carry iron and coal only. A line more direct than the present could be made on which trains at 20 miles an hour could bring 400 tons each of paying freight, into town, at a prime cost of not more than 4d. per ton per mile, including, of course, the return of the empty wagons, and the freight of coal for 120 miles need not exceed 3s., and that of iron 5s. No opposition from existing interests should prevent the carrying out of undertakings like these.

The present year has shown, more than ever, the necessity for greatly improved means of communication across the Channel to France. Within sixteen years there have been four great international exhibitions, two in Paris and two in London; and they who believe, or affect to believe, that that of the present year, the greatest and, in its practical aspects, by far the most important of them all, will be the last of the kind, greatly deceive themselves, or try to do so, and greatly undervalue the modern tendency to relaxation and the craving for variety which increasing means must always engender. In a happy inspiration we once made an attractive exhibition, and we can and will make others yet. That of 1862 was as unattractive as want of taste could make it, and the French, with all their taste, have this year done even worse, and it is a great fact that these exhibitions thrive, despite their ugliness. But leaving exhibitions, as incentives to crossing the Channel, to one side, the increasing ordinary (traffic between Dover and Calais, and Folkestone and Boulogne, demands either a tunnel or a great railway ferry, having almost the stability of a bridge. Without entering upon details, it is sufficient to say that the crossing of the Channel is one of the most important engineering problems of our time, and it is certain to be solved before many years in a way wholly different from anything we have yet been accustomed to.

A railway tunnel under the Mersey, between Liverpool and Birkenhead, cannot be long delayed. Even were it to cost a million, which it would not, it would soon repay more than the interest, 50,000l. yearly, upon such an investment. Its earnings would not be comparable with those per train-mile of ordinary railways, but, in the hands of the great railway companies, it would earn as much as

twenty miles of ordinary open line, and be of incalculable benefit to the two ports thus connected.

Much as has been done in India, we have hardly yet begun in that country. What are its few thousand miles of railways to what must follow? What conception can we have of an irrigated India, when millions of acres of parched lands are transformed into rich meadows, giving support to millions of beings now gaining in intelligence, and learning the thousand artificial wants of modern civilisation? Irrigation will transform India into a land wherein a thousand new undertakings will pay, which, otherwise, would never pay at all. We have before us a letter from one of the very highest authorities upon the public works and public affairs of India, and we regret only that we are not at liberty to give the writer's name, as an additional encouragement to young engineers now seeking employment. He says:

"The Secretary of State seems to be now really thinking of doing something about irrigation. They have, as you are aware, sent out twenty-five young civil engineers, and are to send twenty-five more in December, and as many more as can pass a certain test, and have given authority to the local Government to employ any qualified men they can find. I trust, from this, that the discussions about the famine are producing some fruit."

Even steam-cultivation, although perhaps furnishing few opportunities for large investments in single undertakings, nevertheless offers excellent inducements for the investment of a large aggregate sum in many smaller speculations. As a national question, that of steam tillage is second to but few others in its importance, and the statesman, the political economist, and every philanthropist may look hopefully forward to the time when all our arable land shall be tilled by steam, not only with a great saving of labour and expense, but with a great improvement in the crops. No doubt we have yet to learn much of steam-plough science, and of the management of steam-cultivating undertakings, and we may indeed look forward with strong hope to further improvements. But, as it is, it needs only active agitation, the widest dissemination of proved results, and a little faith and energy, to establish a hundred or more steam-cultivating and draining companies of moderate capital in the full tide of success. What may be yet done by amalgamation we cannot now know; but we may yet see something like railway enterprise directed into this new field, and have our steam-farming companies, owning freeholds of their own, and having hundreds of engines under steam, and a capital of a million or so each. Our agricultural engineers may depend upon it that it is quite time to begin, and that in this, as in every race, "Blood will tell."

We are, too, upon the eve of a great change in the structure and working of our Transatlantic steamships, and our Scotias and Russias of the present day must soon be looked upon as representatives of a former period, invested with the respectable antiquity of the Great Western, the Don Juan, the Pottinger, and the other historical craft which figured so well in the early days of steam-shipping enterprise. We now require more and better accommodation and higher speed, express steam-boats, without masts or sails, furnished like hotels, and driven at the rate of 450 knots per day, or 18½ per hour, making the trip from Liverpool to New York in less than seven days. It is easy to put from 15,000 to 17,000 indicated horse power into a steam-vessel of, say, 500 ft. length, 60 ft. beam, and yet drawing less than 18 ft. of water, and to work such engines at 2 lb. per horse power per hour, or, say, about 360 tons of coal a day, or 2500 tons on a voyage to New York, where many of the smaller and slower ships now burn half that quantity. Such boats are not idle schemes, for some of the ablest and largest ship and engine builders on the Clyde have already designed and proposed them, and are prepared, no doubt, to guarantee their performance, although this, in the present state of ship-building and engineering science, is a matter of nearly certain foreknowledge. It is idle to say that the Great Eastern was a failure so far as Atlantic steaming was concerned. She is a slow ship, and, having no consorts, could only leave either side of the Atlantic every six weeks, and needs, at least, a thousand first-class passengers a voyage to make her pay. Passengers will not wait for weeks merely to catch a favourite ship, nor will shippers of goods, especially those of a high value, generally sent by fast steam-ships, delay their shipment. It is not now uncommon for from three to five large steam-ships to leave England, on a single day, for New York, and, including the French Transatlantic line, the passenger always has his choice of the vessels of eight or ten steam-ship companies. No

single ship, however great and commodious, will ever pay between England and America, any more than would a single railway train, however excellent in its accommodations, running once a week between London and Liverpool, and competing with a dozen or more ordinary trains running every day. We must have, and shall have, not a single improved ship, but a line of them leaving England twice or three times a week; a line requiring a fleet of from sixteen to twenty-five such ships to keep it working, and of which the establishment would require a capital of from 4,000,000*l.* to 10,000,000*l.*, according to the number and character of the vessels employed. The prize is open to whoever has the skill and capital to contest it, and such a line would unquestionably appropriate to itself all the ocean travel now going on across the Atlantic, because of the steadiness, comfort, elegance, and speed of its boats, all which, with a large number of passengers, could be secured at the present fares.

THE BREAKING OF RAILS.

Few English engineers can have any clear conception of the rigours of an American winter. Although the city of New York is in nearly the same latitude as Madrid and Naples, or in 41 north, while we Londoners are in 53, scarcely a winter passes in the first-named city in which the mercury does not descend to from 7° to 12° below zero, or 39° to 44° of frost, the streets, meanwhile, having from 1 ft. to 3 ft. of snow upon them, and all locomotion being carried on by means of sleighs or sledges. Further north the cold is still more intense, and we, ourselves, remember how, in the month of January, 1857, mercury congealed in the thermometers at Watertown, in the State of New York (200 miles north of the city of New York), and how a spirit thermometer showed 41° below zero, or 73° of frost, hardly to be exceeded by any spot in the highest polar regions. In Canada the *minimum* winter temperature is often as low as 24° below zero, or 56° of frost; and it may be readily imagined how completely frozen up is the ballasting, or "road-bed," of the railways in the Northern States and Canada during such weather. Indeed, for months together, the "road-bed"—for there is not always much ballast, and the sleepers and rails lie near to the natural soil—are frozen to almost the hardness of granite. Thus tried, axles and engine-tyres, and occasionally, but seldom, the splendid chilled cast-iron wheels which are universally employed in America under the fastest passenger rolling-stock, break, and the rails themselves break much too often. In the winter of 1860-61, Mr. Edward Watkin, M.P., while resident in Canada, as the general manager of the Grand Trunk Railway, changed the under gear of nearly all the six-wheel tenders on that line to the double-bogie system universally employed in the States, and this merely to lessen the breakage of rails—an expedient which proved, by his own account, fairly successful. Rails break, however, even on the lines in the Northern States, where the English six-wheel tender is unknown, and only double-bogie tenders are ever employed. The brittleness of rails in winter is one of the reasons, and we believe it to be an important reason, for the extended adoption obtained by Bessemer steel rails in America, and that under an import duty of no less than 11*l.* 10*s.* per ton, payable in gold, at New York, a duty nearly equal to the invoice price of the rails in England. Bessemer steel rails have been taken up in the hardest frosts experienced at Crewe and placed immediately under the steam-hammer, and subjected to a series of rapid and vigorous blows, yet they did not show the least signs of breaking. Steel rails of from 75 lb. to 84 lb. per yard, and laid upon supports 3 ft. apart in the clear, will withstand the blow of a 1-ton ram, falling from a height varying between 25 ft. and 40 ft., without breaking, and bending but about 5 in., a test that would instantly demolish the best iron rail ever made. Such steel rails will withstand even the rigours of an American winter, and their extraordinary strength under concussion, a strength never known or imagined with respect to iron rails, no doubt accounts for the wide adoption which steel rails have won in the States, notwithstanding their higher cost, enhanced, too, by an oppressive and nearly prohibitive tariff. Few, too, of the American lines have anything like the great number of trains common on our railways. The number is regulated greatly by the number of engines worked per mile of line, or per hundred or per thousand miles. In England we have about 10,000 locomotives working 13,000 miles of railway. In America they have about the same number of engines working about 35,000 miles of line, each engine making, too, an annual average hardly as great, if, indeed, anywhere near as great, as that made on English lines. Here, we are in the habit of adopting

steel rails only where there is very heavy traffic, and we obtain our steel at from 12*l.* to 14*l.* per ton, whereas it costs from 23*l.* to 25*l.* (gold) laid down in New York. We go into wonderfully minute calculations of the compound interest on the cost of steel as compared with iron rails, a calculation which really bears but little upon the question, forgetting that steel rails save more, yearly, than the interest on their total cost, by reason of the superior line which they make, and that they never break. The breakage of a single wrought-iron rail, under the passage of a fast train through Hatfield Station, not many years ago, cost the Great Northern Railway 13,000*l.* as compensation for the life of the only first-class passenger killed.

THE MECHANICAL ENGINEERS.

THE Institution of Mechanical Engineers has rendered a certain service to the cause of practical science, but its best friends must feel and admit that it has hardly lived up to its admirable opportunities for the improvement of mechanical practice, and the cultivation of a higher order of mechanical thought. It is not, of course, an association of mechanical philosophers, although it numbers among its members many of the first mechanicians in the world; nor is it exactly a professional body, in the sense in which that term is properly understood, but it is rather the representative body of the engineering tradesmen of the kingdom. In this respect its sphere is an honourable one, and the institution is in itself respectable; but an honourable sphere, equivalent merely to a laudable object, and a respectable existence are hardly enough in the case of a body having such great latent powers of usefulness. So long as it remains cooped up in Birmingham, so long as it has practically but one meeting of importance in the year, so long as it awards no premiums for papers, so long as it excludes papers not "communicated" through a member, so long as it has no committees with instructions to report upon subjects of professional and even of commercial importance, so long as it has no coherent council, working frequently and effectively together, so long, in fact, as no presiding and guiding influence is visible in its affairs, so long must the Institution of Mechanical Engineers occupy an equivocal position, one which, if it had enemies, as we are sure it has not, might be described as that of a tradesmen's club or a third-class debating society. For its meetings are undeniably attended to a great extent for business and social purposes, its "papers" are occasionally advertisements in disguise, and its "discussions" are very frequently but the mere interchange of questions and answers upon matters of fact omitted from the paper, sometimes purposely so and by request, as otherwise no "discussion" might arise. It will not be disputed that, except some speaker like Mr. Bramwell or Mr. Siemens stands up, we seldom hear in these so-called discussions any enunciation of mechanical truths, any criticism, any independent and original opinion; but we have much in the interrogative and responsive style, and that where the paper ought not really to have left anything to ask or to reply to.

The secretary is zealous, we freely admit; indeed he is, to a great extent, the "institution" itself; and he edits the papers with real care to have them as full and clear, and the drawings as correct, as possible, and, could he always succeed in these respects, the "discussions" of which we have spoken would be untimely nipped, and the duly instructed members would have only to acknowledge to themselves what they had heard, in silence and in thankfulness. It is hardly, we think, for the best interests of the institution that the secretary, zealous and desirous of doing his best as he is, should so completely represent it as he does, and it has, we confess, made some to open their eyes a little wider than usual to hear him, while, beside the president's chair, check this or that speaker, even when perfectly in order, and direct him as to what he should and should not discuss.

An advantage of the first magnitude possessed by the institution is its immense power of collecting information in every walk of mechanical engineering, and from all parts of the kingdom, and from many places abroad. The movable festivals, or meetings, are of advantage, too, in bringing the members to see for themselves much of which they would otherwise only hear, and perhaps care little about. If the council could and would afford more time to their tasks, and would seek to encourage the best mechanical thought of the country, and would obtain also from committees of members reports upon questions of importance, they might make full use of the advantages we have named. The merely descriptive papers which we now

have, and which are almost always useful, and often very valuable, would then be supplemented by reports and essays of even greater importance. We might have, for example, the results of a full inquiry into the principles and working of the system of water-jet propulsion, of pneumatic railways, and of expedients for working very steep inclines. We might have an important report upon the present use of steel, and the means relied upon to adapt it still further to the purposes of iron. Fast ocean steaming is another subject of great importance, and even an inquiry into the mechanical laws and possibility of artificial flight would not be altogether beneath the institution. The question of heavy ordnance is mainly one of mechanical engineering, and this the representative body in that profession ought from the first to have kept a firm hold of the question, especially with Sir William Armstrong, Mr. Whitworth, and Colonel Anderson on its council. Other subjects, too, of a more general nature deserve liberal attention. The influence and resources of foreign competition, the practical effects of the patent laws, the technical education of workmen, workshop economy, and topics of corresponding interest and importance should be met and dealt with, dismissing the narrow ideas which now repress some of the most useful impulses of the members of such a body. The institution should in this and other ways take the lead in forming mechanical opinion, instead of, as now, leaving nearly the whole task to the engineering press, which far surpasses it also in the number, value, and variety of its merely mechanical descriptions. We could point to scores of important mechanical novelties in our own volumes which have never been brought before the Institution of Mechanical Engineers at all.

Why, too, should not they, as the Civil Engineers have done, establish a benevolent fund, to which the great mechanical firms would contribute nobly, and which would render great and incalculable service in the future to those otherwise helpless, and such cases are always arising even among mechanical engineers? Why, too, should not the institution take steps, if steps be deemed necessary, to establish a system and schools for the technical education of engineering workmen? This is the body of all others to promote such a movement. Let the institution be placed beyond the influence of narrow jealousies, and its sphere be extended beyond that of listening to and discussing mechanical descriptions, and its proceedings would soon acquire a character, and attract an amount of attention, which would make membership a real and desirable distinction. This cannot be done by any one man, however zealous he may be, nor should any one man be permitted to prevent its being done.

WHY NOT TO GO TO AMERICA.

So many young engineers are ready, in these times of dulness, to turn a wistful eye towards America, that it is as well to give them a little advice, as the reality differs greatly from the picture of their imagination. We shall be quite within the truth when we say that we have had at least a hundred applications, personal or by letter, from young engineers, asking for advice or letters of introduction, with a view to starting life in America. And although that country offers certain advantages, we have never encouraged any young English engineer to think of making it his home.

With respect to civil engineering, such a thing as the "profession," as the term is understood in this country, hardly exists in America. Engineers are not paid there, as here, by a commission upon their work, but are engaged at fixed and generally very moderate salaries, and are at least supposed to devote each his whole time to a single employer. He, of course, selects his own assistants, but the company or individual employing him pays their salaries—and, as a rule, but few are engaged at all.

There are thus no great engineering offices, nor is the "profession," such as it is, centred at any one great capital, like London, nor in any one leading town. There is but little association among American engineers, and there is no representative body of the profession like our Institution. Engineers have little or none of what with us is known as parliamentary practice, the governing bodies in America seldom troubling themselves with engineering evidence of any kind, and in several of the States there are in force what are known as "general railroad laws," whereby any railway company may be formed, without inquiry, much in the manner of a limited liability company here. The "profession" is, in short, less respected and less profitable in America than in England, and we are sure we do not overstep the truth when we say that

there is, in America, a prejudice against Englishmen as such, especially those who are suspected of conservative feelings and of attachment to the Established Church.

As to engineering assistants, the American engineer, apart from his own relatives and friends, has his pick of the graduates of several large engineering schools and polytechnic colleges, such as even we in England might establish with advantage. There is the Lawrence Scientific School, in connexion with Harvard University at Cambridge, near Boston; the Rensselaer Polytechnic School at Troy, New York; the Civil Engineering School of Union College at Schenectady, New York; a polytechnic school in Philadelphia; engineering classes at many of the colleges; and so on, down to the enterprising gentleman near Chicago, who *advertises*, "To be a surveyor, thirty dollars; to be a civil engineer, sixty dollars!" Is it any wonder, then, that engineers in America sometimes unite the duties of their profession with those of land-surveying, school-teaching even, and occasionally *preaching*? We knew, a few years ago, a young gentleman who was chief engineer of a new line of railway, to be, when finished, 340 miles long, and whose salary was 240*l.* a year. We have known but few American engineers, of whatever eminence, to receive a salary of 1000*l.* per annum, although in very rare instances 2000*l.* has been paid. We are speaking of gold payments, before the war. Since then salaries have been increased; but the cost of living has also increased, and in a much higher ratio.

With respect to mechanical engineering, engine-factories and kindred establishments are, of course, neither so numerous nor extensive as here. And none employ anything like the number of draughtsmen to which we are accustomed in such factories. A single draughtsman is commonly reckoned enough for a large locomotive factory or an extensive railway workshop, and his duties are confined chiefly to making large-scale skeleton drawings for fixing centres, &c. We have known large locomotive works, turning out a hundred engines a year, in which no transverse section of any engine existed, the position of the journals upon the axles, and other matters of a like nature, being shown by cross-marks upon 1 in. square wooden staves, of which a small bundle was laid away somewhere in the pattern-shop or in the foreman's room. It will be understood, therefore, that mechanical drawing is not an art very extensively practised in the States, and the young engineer would be edified to see how much is done by a few marks cut with a knife into a board, full-size, by the "boss" (Yankee for master), and how much is left to the pattern-makers. At the same time, the young engineer who wishes to see America as a matter of observation, and who likes a little knocking about, will not, perhaps, do badly in going. He will find sharp but, as a rule, honest and kindly people, most of whom believe in the natural superiority of everything American over everything English. The Americans are a good deal like the Scotch, and share with them many admirable qualities with a few pardonable vanities. If the American *does* boast, he is unconscious of it. He speaks only from an honest conviction that everything American is the very biggest and best of its kind "in all creation."

The young English engineer must bear in mind that in going across the water with the intention of returning after a longer or shorter period, he will not be considered by his home friends to have been in the best school, and however intrinsically valuable his American experience may be, it will not greatly add to the chances of his subsequent employment here. We are in the habit of thinking American practice crude, having much of the rule of thumb, and as wanting, generally, in solidity, care, and what we term professional conscientiousness.

Workmen going to America may do well, especially in the West, for there is little or no demand for English labour in the large Eastern cities. In any case we should not recommend the married workman with a family, large or small, to go to America, nor the workman carefully trained to one kind of work only. It is more the pushing, adventurous, and more versatile class of men who get on—useful men in new countries, but of which Englishmen do not care to see the number greatly increased here, inasmuch as were these the general traits of workmen, the conditions of labour would be often disturbed, and the great operations of industry correspondingly interfered with. At the present time trade is generally bad in America, and it is not so easy to obtain employment, while also the cost of living is greatly beyond anything to which the lower and middle classes have ever been accustomed in England.

MR. FAIRBAIRN'S TRIALS OF STEEL.

THE important series of experiments, made by Mr. Fairbairn, upon the strength of steel, and recorded by him in a paper read before the British Association, at the Dundee meeting, may suggest the idea that steel is not as uniform in its quality as might be desired. The tabulated results (see *ENGINEERING*, of September 20th, pp. 270 and 271) show considerable variation in tensile strength, and an even greater variation in the "work done" to produce rupture; that is, the product of strain multiplied into elongation. Nothing is more important than that users of steel should understand that it is easy to produce almost any quality of steel desired, and that the harder and stronger qualities have less extensibility than the softer and tougher makes. Had Mr. Fairbairn said to the makers, "I wish to have one hundred samples of your 'steel, of any quality you choose to send me, but all *alike* in quality," he would have had very uniform results, for any first-class steel-makers can now produce a hundred or a thousand samples of steel which shall vary less in quality than if they were of standard makes of iron. But Mr. Fairbairn imposed no conditions, and we know that certain makers purposely sent him, in the belief that he wished sent to him, samples of *all* the qualities of steel they produced. It appears from the tables that Messrs. Charles Cammell and Co.'s steel gave the very highest results in respect of the "work producing rupture." The first, second, and third samples were of crucible cast steel of various tempers. The fourth was ordinary double shear steel. The fifth and sixth (the fifth giving the very highest result of any tried) were Bessemer steel; the fifth as made for steel tyres, and the sixth for boiler-plates. In both the last-named specimens the tensile strength was about one-half greater than that of Lowmoor iron; but the tensile strength multiplied into the elongation exceeded anything ever before recorded of steel in bars, this being what is called the "dynamic value" of the metal, and, in so many words, this is its practical value for the purposes of construction. It should be fully understood that any quantity of steel of any quality recorded in Mr. Fairbairn's tables can now be made with as much uniformity as prevails in Lowmoor iron. Messrs. Cammell and Co. made the two thousand steel suspension links for the Prague bridge, and out of these but five links were condemned, although subjected to a very high tensile strain—a strain which the makers protested was excessive and needless. We are pleased to see Messrs. Cammell's steel placed so highly in this important series of tests, and it need not be doubted because of the apparent variability in Mr. Fairbairn's results that any quantity of any recorded quality can be made.

MYSTERIES IN MANUFACTURES.

WE published in our last number a letter addressed to us by Messrs. McHaffie, Forsyth, and Miller, of Glasgow, contradicting our statement that the material employed by them in the cupola for reducing the contents of silicon and graphitic carbon in the pig iron is principally oxide of manganese. We have no desire to dispute this point, nor do we intend to comment upon the singular fact that manufacturers who take so much care to keep the public in the dark about the precise nature of their process should be so anxious to enlighten our readers on that particular detail. Messrs. McHaffie, Forsyth, and Miller have, however, gone a little further, by stating generally, that steel castings such as they make could not be produced in the manner described by us. With regard to this we cannot permit our readers to be misled or mystified. There was a time when the preamble, "It is well known 'to metallurgists,'" could be used with impunity for almost any assertion, because at that time very little was known to metallurgists in general, and those few who possessed some knowledge took good care not to communicate it to others. This time, fortunately, is long past. "Metallurgists who have given the manufacture of steel from pig iron their study" know that the presence of manganese in the pig iron has a tendency to keep out the silicon, and to convert graphitic into combined carbon. Those who doubt this fact will learn something by a visit to the blast furnaces where manganitic iron ores are smelted, as, for instance, the district of Siegen, where the spiegeleisen is made, or the Georgs Marienhütte, in Hanover, which makes grey iron for the Bessemer process from ores containing a small percentage of manganese. Spiegeleisen, although charged with 5 per cent. of carbon, contains no graphite, and its percentage of silicon is very low. This is due to the presence of manganese. The grey iron,

which contains some 1½ per cent. of manganese, is at the same time comparatively poor in silicium. Attempts have been made at the Georgs Marienhütte to charge the iron with a greater percentage of manganese by adding richer manganese ores, and the immediate result was the reduction of the percentage of silicium to such a degree as to make the iron almost unsuitable for the Bessemer process. A still further addition of manganese turned the graphite into combined carbon, and produced spiegeleisen. There has been even such a thing made at these furnaces as mottled spiegeleisen, i.e., a mixture of grey iron and manganesic white iron. The action of the different elements in the cupola is precisely the same as in the blast furnace, and there can be no doubt that the presence of manganese there will produce similar results. The addition of oxide of manganese has, as a rule, been unsuccessful, on account of the difficulty of bringing the manganese into proper contact with the iron, since the powder, whether introduced through the tuyeres or charged at the top, was carried off by the blast before it could be reduced. The idea of enclosing the powder in slowly melting iron pots appears, therefore, to be a very sensible mode of obviating this difficulty, and if the iron pots of Messrs. McHaffie, Forsyth, and Miller do not contain oxide of manganese, all we can say is, that they *ought* to contain that substance. With all this we do not, however, advocate this mode of steel-making, although its products may be of a very good quality with proper care and selection of raw materials. The removal of silicon by the manganese is only partial, and a sensible proportion of that substance is always left in the iron, which cannot be extracted by subsequent annealing. There is also a tendency to produce mottled iron by leaving a part of the graphite uncombined, a tendency which has most chance of being particularly active in the centre of massive castings. These, after annealing, would probably be found "rotten" in the centre, or deficient in strength. The simplest modes for making steel castings are the process of M. Martin, in Sireuil, and Mr. Bessemer's plan of mixing cast iron with liquid steel in the converter. With regard to the latter, it would be equally feasible to cast a metal free from silicium, and containing a surplus of carbon, which may be removed after solidification by annealing. It is more than probable that the Bessemer process will be found capable of producing cheaper and better steel castings than any other process now in use, if the same amount of care and attention is given to this branch that has been bestowed upon most other modes of making steel or malleable iron castings.

FRENCH ENGINES IN ENGLAND.

BESIDES the famous French locomotives made at Creusot, from Mr. Sinclair's designs, for the Great Eastern Railway, another French maker, M. Quillacq, of Anzin, some time ago sent a pumping-engine and a pair of winding-engines to a colliery near Newcastle, which is much like sending coals themselves to that canny town. In his report in Class 47 of the Paris Exhibition, Mining and Metallurgy, Mr. Warrington Smyth refers to the incredulity expressed by some of his co-jurors as to the fact that French engineers could thus compete with English makers on their own ground, but Mr. Smyth had obtained a written communication from the owners of the pit, stating that these engines were both "lower in price and of better finish" than the engines tendered by English firms, and moreover that, after eighteen months' use of the pumping-engine, it had proved "highly satisfactory," the winding-engines not having been so long at work.

It is most important to know how far the facts reported of these engines apply generally to French as compared with English work. Coal and iron are abundant, but not very cheap; and there is plenty of skilled labour at Anzin, which is in the department of the Nord, not so very far from Dover, nor even from Newcastle.

M. Quillacq, who is also mayor of Anzin, served an apprenticeship with the famous firm of Sharp, Roberts and Co., of Manchester, and afterwards worked at Maudslays'. We shall hope to escape the charge of impertinence in saying too, that, in speech and appearance, the worthy mayor and engineer might be readily mistaken for a handsome Englishman, even yet hardly arrived at middle age. Hundreds of our readers will remember an excellent pair of horizontal winding-engines which he exhibited at the International Exhibition of 1862, and which occupied a place in the western annexe near the French marine engines (not to be compared with them in quality of work). M. Quillacq's vertical winding-engines in the Paris Exhibition are also a good job.

The French engineers are indisputably taking much of the foreign trade which we once considered as our own. When we were at Lille, last winter, we saw locomotives, part of an extensive order, in course of construction for Russia; and Schneider and Co., of Creusot, have just secured eighty more for the same country, in the face of keen English competition. In Paris too, where, one would suppose, manufacturing advantages are still fewer, Gouin has made some very large iron bridges for Italy. It has often been asked whether M. Schneider and M. Gouin do not enjoy special advantages by reason of their connexion with the French Government, the first named engineer being the president, and the second the vice-president, of the Legislative Assembly, and both of them personal friends of the emperor. If there be anything in this we need not suppose M. Quillacq to share in such advantages, and the question again presents itself, "How is it that the French engineers can beat us, even 'on our own ground'?"

STEAM-ROLLER FOR BOMBAY.

WE were present yesterday morning at the trial in Hyde Park of a steam-roller which has been constructed by Messrs. Moreland and Son for the municipality of Bombay. This roller is upon the principle patented by Mr. D. Thomson, and presents many features of dissimilarity from any other steam-roller which we have hitherto seen.

The whole machine, engines, boiler, roller, and steering-wheels is enclosed within a rectangular boiler-plate framework, 8 ft. broad over all, and 18 ft. long. The plates of this framework vary from ¾ in. to 1 in. about the engine, and are ½ in. thick over the remainder; these are strengthened, horizontally and vertically, with angle and T irons rivetted on the outside of the plates from top to bottom, and along their entire length. The top is covered with flat boiler plates, and an iron hand-rail runs all round for the protection of the men working the engine and steering the roller, who are stationed there. Projecting up above this roof, and at one end of it, are placed two inverted vertical cylinders, each 11 in. in diameter and 1 ft. 6 in. stroke. These work upon one and the same crank-shaft, placed immediately below them, on either end of which is a small drum round which works a pitch-chain, which communicates motion to the roller itself, and which acts as the driving-wheel of the whole machine. The valves are worked by eccentrics on the crank-shaft, communicating with a link motion, which is worked by a lever placed on the roof close to the steering apparatus, both of which can thus be attended to by one man.

The roller itself is 7 ft. 6 in. in diameter and 6 ft. wide; it is formed entirely of boiler-plate rivetted together, and strengthened internally by stays; an external plate of iron is bolted on over the drum, which can be replaced by another so soon as it may have worn out. In the case of the engine we are now describing, the roller is made in two pieces, and thus forms in reality two rollers, both upon the same shaft; but this, we were informed, has been done chiefly for convenience of shipment. At either end of the roller is a small drum, considerably less in diameter than the roller itself, over which the pitch-chain works which communicates motion to it from the crank-shaft. The steering-wheels, of which there are two, are 3 ft. 6 in. in diameter and 14 in. broad; from the axle, at each end, pass up through the framing two rods, at the upper end of each of which is a toothed segment, into which a worm-wheel works from a shaft connected with the steering-wheels. There are two steering-wheels intended for two men; but even on rough stones the machine can be easily steered by one man with one hand. Both the roller and the guiding-wheels are on springs, which, we observed, admitted of considerable play, and must take off considerable strain from the framework, which, however, from its great depth, seems well calculated to sustain any amount of strain to which it could be subjected. The boiler, which is nearly over the guiding-wheels, is of a circular vertical form, 3 ft. 6 in. in diameter, with tubes on the Field principle. The steam is taken off from the top of the boiler by pipes which run along the top of the framework to the cylinders, and the exhaust is similarly led back by pipes and emitted below the firegrate; thus perfect combustion is secured, and there is no puffing noise of exhaust steam to be observed whilst the machine is in motion. In the centre of the roof is a circular tank rising above it, capable of containing about 1 ton of water, and the feed to the boiler is effected by means of an injector.

The total weight of this machine is 25½ tons (with water and fuel), of which 21½ tons is carried by the roller, and the remaining 4 tons by the guiding wheels. Of the former weight the roller itself contributes 8 tons, and the remaining 13½ tons is made up by the boiler, engines, frameworks, &c. The boiler works up to from 100 to 120 lb. pressure.

At the trial on Thursday morning the road in the park between Prince's-gate and Queen's-gate was barricaded, and it was on this portion that the roller was at work. The whole road was picked up along its centre, fresh granite laid down, strewn over with sand, and well watered. The roller certainly did its work well, and after twice passing over it, the new granite was so consolidated as to present a surface such as the most fastidious could not have objected to. In very few instances did we discover pieces of granite crushed by the roller, but they were for the most part well and evenly consolidated.

We have been promised drawings of this roller, which we shall hope to give in an early number.

BIRKENHEAD.—The receipts of the Birkenhead ferries, from April 24 to September 30, this year, amounted to 16,827. In the corresponding period of 1866, the amount of revenue collected was 16,181. The working expenditure of the ferries was 18,655. From April 24 to September 30, this year, against 18,253. In the corresponding period of 1866. Captain Bartier, the ferry manager, has had his salary increased to 500L per annum. A somewhat larger amount is in future to be carried to the contingent fund in respect to the ferry steamers.

THE LATE MR. JAMES COMBE.

WE regret to announce the death of Mr. James Combe, one of the elder generation of engineers who are now so rapidly passing away from us. Mr. Combe was born in 1806, and entered the profession as pupil to a mechanical engineer in his seventeenth year. In 1826 he became connected with Messrs. Rennie, and remained with them for twelve years, at first in a subordinate capacity, but for the latter half of the time as one of the chief assistants of that firm. In September, 1837, he obtained the appointment of resident engineer to the London, Brighton, and South Coast Railway, an appointment which he resigned in March, 1848, in order to devote himself exclusively to an extensive private practice which he had acquired. Failing health compelled him gradually to abandon professional pursuits, and in 1857 he retired from business, and left London. From that time he resided in seclusion at Torquay until his death, which took place on the 1st of the present month.

Mr. Combe was elected as an associate of the Institution of Civil Engineers on the 30th March, 1830, and was transferred to the class of members on the 5th March, 1844. His proposal paper of the first-named date bears the signatures of these seven great engineers—W. C. Mylne, Sir William Cubitt, George Rennie, J. U. Rastrick, J. M. Rendel, I. K. Brunel, W. Tienay Clark, Sir J. Macneil, James Simpson; and all of these, except the last two, are dead.

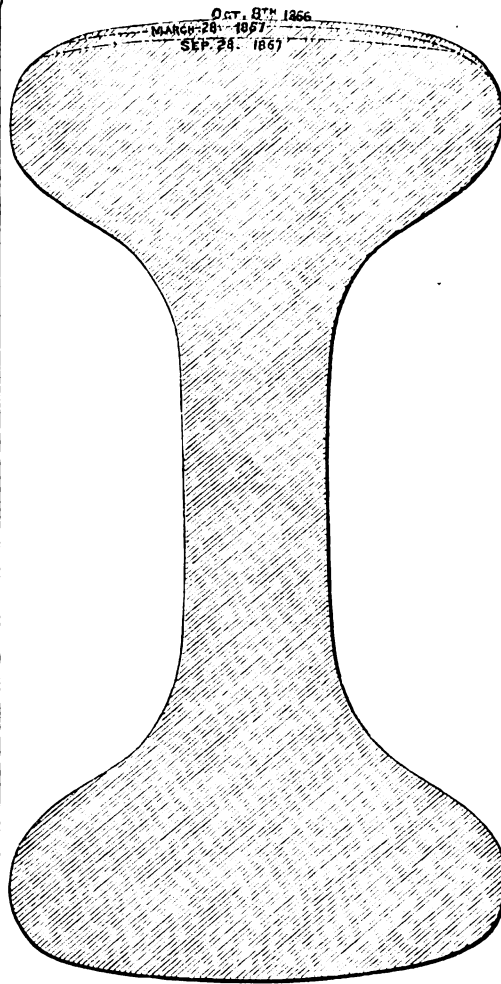
STEEL RAILS.

TO THE EDITOR OF ENGINEERING.

SIR,—Referring to your issue of the 5th of April last, vol. iii., No. 66, p. 315, I beg to hand you diagram of the Barrow Bessemer steel rail therein referred to, showing the extent of wear on it for the six months from the 29th March to the 28th ult., 1867 days.

As this period embraces the summer half of the year, the average daily traffic over the line of rails amounted to 34,742 tons, as against 27,268 tons for the previous period, and gives a total for the 183 days of 6,357,786 tons, as against 4,635,560 tons for the previous 170 days.

On the 28th ult., I placed a new iron rail (previously



weighed) in the line opposite this steel rail, and also carefully cleaned and then weighed the latter, so that at the end of the current six months the comparative wear of steel and iron rails, under exactly the same circumstances, will be accurately ascertained.

North British Railway, Glasgow,
October 8, 1867.

Yours faithfully,
JAMES DEAS.

WATER SUPPLY OF LISBON.—A contract has been secured between the Portuguese Government and a company of Portuguese capitalists with reference to the future water supply of Lisbon. The company is to start with a subscribed capital of 1,120,000L (which may be carried to 2,000,000L); and it is to be constituted within six months, dating from July 2, 1867. It is proposed to bring to Lisbon the waters of the river Alviella by a canal 65 miles long. By this means it is calculated that a supply of 75 gallons per day will be assured to the population of Lisbon, which at present amounts to 220,000 souls.

M. AUGUSTE PERDONNET.

On Friday last, the 4th inst., the funeral of M. Auguste Perdonnet, the celebrated civil engineer and the director of the Central School of Arts and Manufactures, who died recently at Nice, took place in Paris amidst a great concourse of friends and of *savants*.

Several funeral orations were pronounced upon his tomb, and amongst them one by M. Dumas, the eminent chemist, the following extracts from which well merit a place in this journal:

"Gentlemen,—In order to attract the large assemblage which throngs round the tomb to which the mortal remains of M. Perdonnet are about to be consigned, the talents, the public services rendered by the departed and the *clat* of his life were not sufficient, however great these may have been. A benevolent and large-hearted man alone could inspire the affection, the respect, the pious gratitude which is so unanimously expressed by this mournful multitude. M. Perdonnet had not only been endowed by Providence with rare talents, a high station, and an independent fortune, but he had also received from God the spirit of charity.

"Whenever occasion served, his knowledge, his time, his influence, and his purse were set at work: his knowledge, to enlighten the ignorant; his time and influence, to help the weak and friendless; his purse, to relieve all kinds of misfortunes. Those who have watched his life know what has become of the proceeds of his many years of labour, mixed up as they have been with the greatest undertakings. M. Perdonnet, who looked upon his private fortune as a kind of trust, looked at the same time upon the fruits of his own labour as belonging to those young talents which are stopped in their progress by want, and to those institutions which enlighten and moralise the labouring classes. The sorrow of this assembled multitude is due to the fact that M. Perdonnet practised Christian charity in all its forms.

"M. Perdonnet loved youth; he loved its movements, its life, its generosity, its ardour. He was full of sympathy and indulgence for youth; and if on certain occasions he was firm and severe, it was because a higher interest—namely, that of the school—demanded it. He loved the Central School passionately, as being one of those powerful instruments for preparing men capable of directing society in its struggles with nature, and of ensuring its material progress towards order and enlightenment.

"The Central School was hardly established when he was called upon to join it, and he was the first to establish a course of lectures on the construction of railways. He was one of the initiators of this remarkable industry which has revolutionised the world, and at the head of whose multifarious works may be found hundreds of M. Perdonnet's pupils. The elementary treatise on railways and the *Portefeuille de l'Ingénieur des Chemins de Fer* will soon be received as classical works. They embody at once his learned lectures, and the universal experience of the engineers of the two worlds. For when it was necessary to gather information, to control a new method, or to make known and apply a new discovery, M. Perdonnet spared himself neither in distant journeys nor expense. Received everywhere as an accomplished master, he was able to gather together precise data respecting all the facts which cropped up in the still novel industry of railways; and he has contributed more than any one else to its rapid extension by the exact information which he has published, by his impartial criticisms, and by his enlightened judgment.

"Placed in the centre of the greatest undertakings, on the one hand, and in the midst of a choice youth, on the other, animated, moreover, by a love of the good, and full of sympathy for his pupils, it was natural that he should desire at once to give to the railway companies well-informed assistants, and prepare a career for the engineers whom he had trained. No one more than he has helped to place the pupils of the Central School upon the road to labour and to fortune. Long before receiving the title of director of the school, he exercised in this sense its most serious attributes with all the ardour and all the refinement of his soul, exercising an indirect and discreet supervision of the works and the career of his old disciples, whose circumstances sometimes bettered themselves, when they were worthy of it, under the pressure of an influence which never revealed itself.

"Thus we find M. Perdonnet in the elevated sphere of instruction of a high degree, and thus we find him again in the more extended domain of instruction which he has founded in favour of the artisans, under the name of 'Polytechnic Association.' Animated towards the masses with a sincere love, he has given them much, and never demanded anything of them. In return for the good which he has wrought for them, he never accepted but new obligations, his sacrifices becoming greater with the very success of his works.

"He served the masses with an absolute self-sacrifice. He wished to see them more enlightened and better. In his familiar language, in which sentiments full of good humour were mingled with ideas of great depth, he sometimes gave them hard words of advice, which, however, were always listened to with respect, for the people knew that they were beloved by this chief who never flattered them.

"Be who you may, if you enter the workshops and find there foremen or workmen familiar with the details of practical geometry, of mechanics, of physics, or of chemistry, who prove by their language that our great writers are no strangers to them, and by their sentiments that they have regulated their conduct by the law of morality, remember Perdonnet with gratitude, for you find yourself in the presence of pupils formed by the lectures which he has instituted, who have learned under masters of his choice to combine with a better workmanship a more thoughtful conception of nature, and a higher respect for the dignity of man.

"Be assured, these workmen whom education has made better, these souls whom it has ennobled, have not on that account taken a dislike to work! No; but work has ceased

to be for them an unintelligent and mechanical operation. It has become worthy of man, who submits to it as to a natural law; instead of being the tyrant of thought, work has become its slave, and the hand executes only that which the mind has understood and decreed. Let us not be astonished, therefore, at this great assemblage, and let us see in it, with a certain degree of satisfaction, that men remember more than is generally believed the good which is done for them, and that public gratitude follows in the wake of all truly disinterested sacrifices. Why are the most eminent engineers and the most renowned administrators here to render a last homage to these mortal remains? It is because Perdonnet more than any other man has contributed to strengthen their power over matter. Why have these workmen, pupils of the Polytechnic Institution, quitted their workshops to accompany them with veneration? It is because they had accepted their venerable president as exercising a real power over their souls. Why are the pupils of the Central School of Arts and Manufactures all present here? It is because Perdonnet, before being the director of the school, was to its pupils a devoted master, an indulgent friend, and a thoughtful father.

"M. Perdonnet, who was Swiss by origin, might have chosen his place of rest far from the din of this great city amidst the calm of his native mountains. But it is good that his ashes should repose near us, under the guard of the pupils of the Polytechnic Institution and of the Central School, that these may teach future generations to preserve a pious respect for a good man, whose life was made up of two parts—the one devoted to labour and glory, and the other to self-sacrifice and charity—who leaves this world empty-handed, without other profit than the labours of half a century, the permanent marks of his works, and the fruitful imprints of his goodness."

THE KANSAS CITY BRIDGE.

THE Americans are beginning to bridge their rivers boldly. The Mississippi is spanned at Rock Island and at Clinton; and this year bridges are being built across it at Burlington and at Quincy, whilst next year it is proposed to cross it at Dubuque and at Keokuck. The Ohio is crossed at Steubenville; a bridge is now building over it at Louisville, and two more are contemplated for next year at Parkersburg and Bellair.

Thus far only one bridge has been started over the Missouri; but it is intended to commence constructing bridges at Omaha and St. Charles next spring, while two companies propose to bridge it at St. Louis, one of them designing to erect a steel arch of 520 ft. clear span. The bridge, which has just been commenced over the Missouri, is at Kansas city, and it has been designed to allow of the passage of the ordinary road-traffic and of the trains of the Cameron Railroad over the same floor, the bridge being used alternately for trains and road-carriages. For this purpose the floor of the bridge will be made 18 ft. wide in the clear, and will be laid with a street-rail and Nicholson's pavement. The admission of carriages upon the bridge will be regulated by watchmen, and each end will be provided with gates and signals, so as to preclude the possibility of teams and railway-trains being upon the bridge simultaneously.

As the time required to cross the whole bridge, at a speed of five miles per hour, will be but a fraction over three minutes, the detention to the road traffic must be quite slight, as even with a traffic of ten trains per day the crossing of teams cannot be interrupted over one hour in the aggregate.

It has been thought both safer and more convenient to make this arrangement than to separate the different classes of traffic by placing the roadways either side by side or one above the other. In the former case it was considered that there would be great danger of accident from the frightening of horses by meeting a train on the bridge, and in the latter, the carriage road would have to be on top of the truss, and would be placed so high (not less than 80 ft. above the bottom on the other side of the river), as to make it difficult of access, and seriously to impair its commercial value. By the arrangement adopted the public may feel quite safe in crossing the bridge, while it amounts to no more than a possible detention of five or six minutes to a train until the floor can be cleared of carriages.

Provision is, however, made in the putting down of foundations, so as eventually to widen the bridge should increasing business demand it.

The arrangement of spans which has been adopted is as follows:

	ft.
1 shore span over Pacific Railroad of	70
1 span reaching to channel, of	135
1 pivot drawn span, of	360
1 main adjoining span, of	250
2 spans of 200 ft. each	400
1 span reaching to north shore	180
Total length	1395

It is designed to build the drawbridge entirely of iron, and to open and shut it by steam power. The great length of this draw is required, by the law of Congress, and is fully 60 ft. longer than the longest bridge of the kind ever before erected, the one at Rock Island being 280 ft., and that at Clinton, 300 ft. long. The plans for this span have not yet been decided on, the engineers being engaged in comparing estimates of the cost of various arrangements, and having issued circulars inviting proposals from the principal bridge builders in America.

The other spans will be built of a combination of wood and iron, in which the parts not exposed to fire and receiving strains of compression will be of wood, while those parts which are either exposed to sparks or cinders from the locomotives, or have to do duty in tension, will be of iron. Mr. Chanute, the chief engineer of the bridge, states as the reason for the adoption of this combined system of construction, that the accumulated interest alone on the sum saved by the proposed arrangement, would replace the wooden parts every

seven years, while they were quite safe, with proper protection, to last 15, and possibly 20 or 30 years; that wooden bridges, well housed in, had lasted in America 50 and 60 years; and that while it was unsafe in a valley so exposed to violent wind gusts to house in a whole bridge, the parts which he designed to make of wood could be effectually covered and protected from the weather, so that even allowing a considerable sum yearly for insurance and repairs, it was probable that the accumulated interests on the sum saved, would rebuild the bridge entirely in iron, at the expiration of the life of the first structure.

This argument would seem to derive some force from the present very high prices of labour and material in America, consequent upon the war, so that fifteen years hence an iron bridge may be built as cheaply as a wooden one could now be.

It is, however, in the foundations, and not in the superstructure, that the greatest difficulties are to be overcome. The river at this point has a general fall of 14 in. per mile, and runs with a velocity ranging from 3½ to 9 miles per hour, according to the height of the water. The current is at present comparatively gentle, being 4½ miles per hour; yet such is its force, that piles driven down from 12 to 15 ft. into its bed, are washed out in three or four days, and cuttings or deposits occur at any obstacles placed in the current to the extent of 15 or 20 ft. in as many days. The soundings taken from time to time by the engineers show that during the spring floods the river scoured out some 30 ft. of its bed, and that from 15 to 20 ft. of this has been again filled up with sand as the river subsided.

The bed rock has been ascertained by borings to extend entirely across the river, but is overlaid on the north side by a deep deposit of quicksand. The deposits in the river to the rock, at the site of each of the piers, are as follows, at the present stage of water; the numbering being from the south, or city side:

First pier	21 ft. water and	2 ft. sand
Second	25	8
Third	19	23
Fourth	10	45
Fifth	5	62
Sixth	3 ft. above water	83
Seventh	3	97

In view of the constant shifting of this sand, it has been decided to go down to the rock with the foundations of the first four piers, and to do this, in such a current, it has been found necessary to originate many new devices, and to invent some new processes. Experiments already made have resulted favourably, and the engineers seem to have full confidence in the success of their plans; and they have undertaken to go down 40 ft. or 45 ft. into the silt without the use of the pneumatic method.

The chief engineer of the bridge is, as we have stated, Mr. O. Chanute, and his principal assistant Mr. R. H. Temple. The erection of the foundations of this bridge will involve many engineering difficulties, and we hope, as the work progresses, to lay particulars of it before our readers.

THE SOCIETY OF ENGINEERS.

VISIT TO THE SOUTHERN THAMES EMBANKMENT AND BLACKFRIARS BRIDGE WORKS.

ON Friday last a large party of the members and associates of the Society of Engineers paid a visit to the Southern Thames Embankment and the new Blackfriars-bridge works, the excursion forming the last of the pleasant visits to engineering works of interest, which have, according to the Society's custom, taken place during the summer recess. The excursion on Friday was quite as interesting as those which preceded it; but, owing to the pressure on our space this week, we are compelled to postpone giving any account of the works visited. We may, however, mention that at the Southern Thames Embankment the visitors were met and shown over the works by Mr. Whittaker, Mr. Webster's representative, whilst at the Blackfriars Bridge works they were received by Messrs. Thorn, the contractors and their engineer, Mr. F. W. Bryant. At both places every pains was taken to explain fully to the visitors the manner in which the works were being carried out, and at both places there was much going on that was interesting. At the Blackfriars-bridge works especially there have been many engineering difficulties to contend with, and these difficulties have been most ably met by the contractors and their engineer.

THE ATLANTIC AND GREAT WESTERN RAILWAY.—The report of the committee of investigation of the Atlantic and Great Western Railway, consisting of Sir William Russell, M.P., and Messrs. Crawshaw Bailey, M.P., Thomas Cave, M.P., John Fildes, M.P., and F. W. Oewel, of Amsterdam, is a clear document, and so far satisfactory that it seems to demonstrate the intrinsic value of the line, and its ability, within a moderate time, to meet all the mortgage charges existing upon it. The committee propose that the interest should be deferred on the first divisional bonds for two years, on the second for three years, and on the consolidated bonds for four years from the 31st of March last, when they consider it fairly certain that payments can be resumed, and that the road will have been placed throughout in perfect condition without a floating liability of any kind. An earlier resumption would in their opinion be practicable, but for the fact that they have found the state of the line much worse than had been anticipated, and such as will necessitate, according to an estimate by Mr. Trevithick, an outlay of earnings to the extent of \$2,600,000. Already, however, during the six months since the appointment of a receiver, its condition has experienced a great improvement. Suggestions are at the same time made for an arrangement of the open debts of the company, and the future position of the share capital.

"VERY LIKE A WHALE."—A French savant has likened the quickness of volition in an animal to the telegraph. He tells his class: When a whale is harpooned the nerve affected instantly telegraphs to the creature's brain, "Harpoon in tail!" upon which the brain telegraphs back, "Jerk tail and upset boat." What a wonderful thing is science!

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Clyde Shipbuilding for September.—The shipbuilding trade at the various ports on the Clyde continues moderately brisk, but far from the condition which the various shipbuilding firms are capable of. Several contracts, mostly for iron ships, were closed during the past month. The ships which have been ordered are not in all cases actually required for immediate use; but owners, both at home and abroad, are taking advantage of the economical terms on which they can secure ships, the cheapness of materials and the low state of workmen's wages being such as have not been seen for some years. The vessels which were launched during the month and nine months ending 30th September, as compared with the corresponding periods in the two years immediately preceding, are as follows:

two years immediately preceding, are as follows:

	1865.		1866.		1867.	
Month ...	Vls.	Tons.	Vls.	Tons.	Vls.	Tons.
Month ...	10	4,580	13	9,230	16	8,500
Nine months ...	193	113,667	163	86,854	143	89,600

It is especially worthy of notice that during September the vessels launched have been of very small tonnage, as a general rule. The following is a tabulated summary of details regarding the principal vessels launched during the past month:

Name.	Character.	H.P.	Tonnage.	Builders.	Owners and Destinations.
Islay Black Swan	Paddle	90	500	Barclay, Curle, and Co. Dobie and Co.	Glasgow and Islay Steamboat Company. Griffiths Brothers and Co., Liverpool.
Paraguay	Screw	60	300	London and Glas. S. and E. Co. Henderson, Coulborne, and Co.	Foreign trade. Bahia Steam Navigation Company. Brazil trade. Hull and Baltic trade. Carron Iron Company. Grangemouth and London trade.
Paraguay	Twin-screw	120	600	Aitken and Mansel	Parana Steam Navigation Company. River Plate trade.
Silver River	Screw	90	550	Seath and Connell	China and Japan trade. Weatherby and Mead, London.
Blonde	"	11	441	Blackwood and Gordon	London and Dun-kirk trade.
Iacare	"	11	362	A. and J. Inglis	James Dalglish and Co., Liverpool.
Ardgowan	Sailing, Iron Composite	0	100	R. Steele and Co.	River Plate trade.
Leander	"	0	1250	J. G. Lawrie	Hamilton and Adam, Greenock.
Helen Burns	"	0	1231	R. Duncan and Co.	East India trade.
Derwent	"	0	903	Barclay, Curle, and Co.	Albon Shipping Company, Glasgow.
Annie Main	"	0	600	A. Stephen and Sons	Rangoon trade.
Medora	"	0	550	Barr and Shearer	Thomas Skinner, Glasgow.
Lochryan	Wooden Ship	0	800	McLea, Rothsay	Singapore trade.
	"	0	65		Coasting trade.

Other Shipbuilding Items.—Paisley, a town a few miles to the west of this city, of which it is sometimes playfully styled a suburb, is doing something in shipbuilding, and promises to do more. From the New Quay, on the Cart, there has just been launched, by Messrs. Donald, Macfarlane and Company, an iron screw steamer, named the Black Eagle, 100 tons burthen, and 66 ft. long. She is intended for canal navigation. On the banks of the same river Cart there is about to be opened an extensive iron-boat building establishment. It will embrace about four acres of ground, and will employ a large number of hands. Carpenters' workshops and sheds are in course of erection on the ground.

Messrs. Robert Duncan and Company, Port Glasgow, launched a twin-screw steamer last week. Her dimensions are as follows: Length, 180 ft.; breadth, 26 ft. 6 in.; depth, 9 ft. 6 in.; gross tonnage, 330 register, and 570 builders' measurement. She is named the Tigre, and is intended for passenger traffic on the river Paraguay, Monte Video. Messrs. Rankine and Blackmore, of the Eagle Foundry, are supplying the engines of the Tigre.

The famous Greenock-built clipper ship, Sir Lancelot, which lately made such an extraordinary run home from China, has been ordered by the Admiralty to be surveyed preparatory to being taken as a transport for the conveyance of stores, &c., to Hong Kong.

The twin-screw steamer, Comercio de Paysandu, formerly mentioned in my "Notes," had her trial trip last week, on the Gareloch. The results obtained in running the measured mile were deemed highly satisfactory, the speed being nearly 12 miles per hour, with a moderate consumption of coal,

and a remarkable absence of vibration. She was built by Messrs. A. and J. Inglis, for Messrs. Bates, Stokes, and Company, of Liverpool.

Mr. Fyfe, the famous yacht-builder, of Fairlie, on the Firth of Clyde, is at present finishing a handsome schooner yacht, of 120 tons; he has a 15 ton cutter on the stocks, and he has also just laid down a schooner of 58 tons. These are all to order, and he is in terms with an Irish yachtman for a cutter of the same size as, but on finer lines than, the world-renowned Fionn, a yacht which has hitherto carried almost everything before her, and which lately came home after winning, during the season, some 500L in prizes.

The New Clyde-built Sloop-of-War.—The newly built screw sloop Dana, 1287 tons, 350 horse power, nominal, machinery by R. Napier and Sons, of Glasgow, steamed out of Portsmouth harbour last week, to make her trial of speed at lightest draught of water over the measured mile, in Stokes Bay. A part of the full boiler power runs were made over the mile, when an unexpected and accidental fracture took place in a small drain-pipe leading from the superheaters, most likely caused by the "jar" from the main feed-pipe, and this accident at once put an end to all further proceedings for the day. During the time the ship was under way, the engines worked with admirable smoothness and regularity of action. Their revolutions, when under full steam-pressure, ranged between 92 and 94 per minute. The vibration of the ship was quite equal to what was experienced in her preliminary run last week outside the Isle of Wight. The Dana will be fast under steam for her tonnage; but if the exerted power of her engines is taken into consideration, together with her improved form of bow, as compared with her sister vessels previously tried over the mile, she may not prove to be what is generally understood as a "successful" vessel.

I have just learned from a private source that Messrs. Randolph, Elder, and Company have contracted with the African Steamship Company to build another ship for their Liverpool and West Coast trade, to run along with the Macgregor Laird, Calabar, Mandingo, and Lagos, all of which were built and engined by the same eminent firm. The measurements of the new steamer are as follows: Length, 265 ft.; breadth of beam, 32 ft.; depth of hold, 22 ft.; 250 horse power. She is to have two high-pressure cylinders of 34 in. diameter, and two low-pressure cylinders of 66 in. diameter, cylinders jacketed, and length of stroke in both cases 3 ft. 6 in.

The Glasgow Pig Iron Market.—During the last week there has not been much change in the state of the pig iron market. Some holders are not much disposed to part with their stock at any prices recently offered, believing that an advance in price will soon be obtainable. As some indication that there is such a prospect, it may be mentioned that the market has generally been firm for some days past. Yesterday a large amount of business was done at 54s. 3d. cash, although on Wednesday last the prices were 54s. cash, and 54s. 2d. one month; even on that day 54s. 1d. one month was taken for a lot of 500 tons. Yesterday's price for No. 1 Gartsherrie and No. 1 Coltness was 61s., and for No. 1 g. m. b. 55s. 3d. The Ardrossan shipments during the week ending 3rd October were 3567 tons, including 700 tons to supply foreign orders; and for the week ending 5th October the shipments of pig iron at Glasgow were 2693 tons, more than half of which was for exportation.

Railway Items.—It was announced a few days ago—apparently on good authority—that the general managership of the Caledonian Railway, about to become vacant by the resignation of Mr. C. Johnstone, on account of ill health, was to be filled by Mr. Smithells, of the Lancashire and Yorkshire Railway, and that he was to receive 2500L of salary the first year, and 3000L per annum afterwards, and that he was to have an assistant at 1000L per annum. It turns out now, however, that this announcement must be taken *cum grano salis*, as it is at least premature, if not even erroneous. Should Mr. Johnstone get his retiring allowance of 5000L and an annuity of 400L, he need not care much who is his successor.

Active operations were resumed a few days since on the Solway Junction Railway, and in the course of the next fourteen days a large body of navvies, masons, and other workmen will be collected and placed on the line, with the view of enabling the company, in April next, to open for traffic the portion of it between Annan and Kirtlebridge, on the Caledonian Railway. The magnificent undertaking of the iron viaduct across the Solway Firth is also nearly completed, and so successfully have the works of the structure been effected, that it has been resolved to erect twenty additional bays or arches at its southern end, next the Cumberland side of the Solway, by which means the viaduct will be lengthened 200 yards, and the heavy sea embankment at that point laid down on the plan will be to that extent shortened, thus affording more sea-room, lessening the tidal force against the works, and so securing greater safety to the public. This resumption of the works is doubtless brought about by the subscription of 60,000L voted by the shareholders of the Caledonian Railway at the half-yearly meeting of the company, held a fortnight ago in this city.

The Highland Railway—whose works you have been illustrating most successfully in *ENGINEERING*—has been proving its great usefulness in one direction at least. Upwards of 700 trucks were ordered at stations on the line last week to take sheep to the famous October Falkirk Tryst. This would represent a transfer of about 30,000 sheep in one week. The sheep traffic on the Highland Railway has been greater this autumn than in any previous year, and greater during the past week than in any during the whole season.

So far as the North British Railway is concerned, the advance made in the fares for return tickets, some months since, is undergoing a modification. The charge for return third class tickets between Edinburgh and Dundee was formerly advanced to 10s.; it has now been reduced to 6s. for tickets issued on Saturday for return on the same day, and to 7s. for those issued on Friday for return on the following Monday. This is said to be a step in the right direction; it may, at all events, somewhat assist to get the company out of the slough of despond in which it has been compelled for some time unwilling to dwell.

Windmillcroft Dock.—This dock is fast nearing completion, and will, in a very few days, be in such a condition that it will be at the disposal of the Clyde trustees for the relief of the shipping in the harbour proper. The dredging-machine is still

at work inside the dock. Two or three days ago the permanent iron swing bridge that has been laid over the mouth of the dock was opened for traffic. It is 143 ft. long, and cost 15,000L. Mr. Duncan, the engineer to the Clyde trustees, has determined to place a dredging-machine in the entrance to the dock on Friday, and when that portion is deepened sufficiently vessels will be admitted. I understand that plans are being prepared for the graving dock which the Clyde trustees have talked about so long, but for which they now intend to seek Parliamentary powers. They are not disposed to purchase the graving docks and ground belonging to Messrs. Tod and Macgregor, the ship-builders. The new graving dock, which is to be constructed for the Clyde trustees, is to be, according to Mr. Duncan's plans, 500 ft. in length, and 20 ft. deep on the sill at top of spring tides. At the last monthly meeting of the trustees, the treasurer mentioned, as evidence of the increase of shipping in the harbour, the following facts regarding the harbour revenue:

	£	s.	d.
Month of September, 1867	12,849	7	3
" " 1866	11,590	8	5
	£1,258 18 10 increase.		
Quarter ending Sept., 1867	35,451	10	9
" " 1866	32,266	16	2
	£3,184 14 7 increase.		

Subscription for the New University Buildings.—The present site of Glasgow University is to give place to a goods station for the City Union Railway, and consequently new buildings are wanted upon another site. The grounds of Gilmorchill, to the west of the city, have been secured; but as the university is not a wealthy corporation, a public subscription, with a prospect of a Government subsidy, was required to enable the authorities to go on with the buildings. Already upwards of 100,000L have been subscribed, many of the subscribers being persons who never darkened a college class-room. Of course, persons ought to subscribe, if they have the means. I feel some pleasure in being able to select from the list of subscribers the names of some persons connected with engineering and allied professions.

	£
Robert Addie, iron and coal master	1000
James Bain, ironmaster	100
William Baird and Co. Gartsherrie	5000
Blair, Campbell, and McLean, copper-smiths	200
G. and J. Burns, shipowners	500
Connal and Co., iron merchants	250
Duncan and Co., shipbuilders	50
James Dunlop, ironmaster	100
William Fairbairn, engineer, Manchester	100
James Fairlie, coalmaster	250
James Ferguson, coalmaster, Lesmahago	1000
John Fleming, engineer and machinist	1000
Houldsworth and Co., Anderson Foundry Company, Coltness Iron Company	2000
D. and J. Hutcheson and Co., Highland Shipping Co.	250
Lancefield Forge Company	1000
James Merry, M.P., ironmaster	1000
Mirrlees and Tait, engineers	1000
Walter Macfarlane, Saracen Foundry	1000
W. and A. McDine, engineers	800
Neilson and Co., engineers	1000
Family of the late J. B. Neilson, inventor of hot blast	1000
Walter, W., and H. Neilson, engineers	1000
Randolph, Elder, and Co., engineers	1000
Neil Robson, ironmaster	500
George Smith and Sons, shipowners	1000
C. J. and John Tennant, chemical manufacturers	3000
Tod and Macgregor, shipbuilders	1000
Corporation of Hammermen	300

This of itself is certainly a noble list of contributions; if it should be the means of obtaining any more from other parts of the kingdom or distant parts of the world to which *ENGINEERING* finds its way my purpose will be served.

SMOKE-NUISANCE INSPECTION.

TO THE EDITOR OF *ENGINEERING*.

SIR,—I write to correct an error in your impression of the 4th inst., in the description of the business of the Government engineer under the Smoke Nuisance Act. I happen to be the individual who minds and belongs to the ironmonger's shop in Maiden-lane which was so minutely described.

Trusting you will insert this in your valuable columns to prevent mistakes,

I am your obedient Servant,
W. SANDISON, JUN.

6, Maiden-lane, Covent-garden, Tuesday, October 8, 1867.

[Mr. Sandison, Jun., must pardon us for stating that his father served a gentleman from our office, not long since, with a half-a-crown's worth of "goods" over the counter. We may mention, also, that on Mr. Sandison senior's card, that gentleman is described as "Civil and Mechanical Engineer, Valuer, &c., 6 and 7, Maiden-lane, Covent-Garden."—Ed. E.]

RAILWAY IMPROVEMENTS.—The last completing link of the extensive system of high-level lines at Battersea, which has been in course of development since 1864, to improve the access to the Victoria Station, was inspected during the present week by Major Rich, R.E., on behalf of the Board of Trade, who submitted the various heavy bridges and other works on the main line of the London, Brighton, and South Coast Railway to the usual severe tests; nine of the heaviest class of locomotives and tenders being employed for the purpose, giving a moving load of 430 tons. The works, which have been carried out under the superintendence of Sir Charles Fox and Sons, as engineers to the company, are of an unusually heavy and interesting character, and do great credit to the contractors for the brickwork, &c., Messrs. William and John Pickering, and the contractor for the ironwork, Mr. James Haywood, of Derby.

NOTES FROM INDIA.

THE cotton shipped from Bombay during the month of July last, amounted to 84,173,661 lb., of which about three-fourths were shipped to China.

The Government of India, it is stated, have vetoed the proposal made by Mr. Walton for the laying of a submarine line of telegraph between Bombay and Kurrachee.

The damage done to the Bombay and Baroda Railway by the recent floods has been repaired sufficiently to enable through traffic to be resumed.

At Allahabad the Ganges has broken through a sluice-gate and inundated the low ground known as the Fort Esplanade. The breach was partially repaired, but the force of the water is so strong that outbreaks are constantly occurring. The place has to be watched night and day with the greatest vigilance.

The line between Ghazeeabad and Meerut was not, according to the latest advice, expected to be opened for traffic before the 15th of September. The construction of this line has been so defective that eight or ten additional bridges and culverts must now be put in. The contractors, Messrs. Brassey and Co., are bound to keep the line in repair for a year after opening.

The *Englishman* mentions that Government has sanctioned the construction of a short branch line at Samnuggur, to connect the Eastern Bengal Railway with the river Hooghly. This will give that railway a landing-place just opposite the coal depot at Biddabutti, on the East Indian line.

From Kurrachee we learn that there is between 20 and 23 ft. of water on the bar of the harbour, which is being gradually worked away by the action produced upon it by the completed portion of Mr. Walker's plans, particularly the Keemaree Groin. A vigorous prosecution of the improvements, as originally contemplated, is now advocated. Some anxiety seems to be felt with regard to the water supply of Kurrachee failing.

The Government of Bengal has appointed a committee to consider the plans of Colonel Fraser, C.B., for small lighthouses at the mouth of the Hooghly, and for jetties at Calcutta. Colonel Fraser proposes to build five lighthouses from Point Palmyras to the Mutlah, and to begin with Saugor Island. This plan will dispense with the present lightships, will save no small number of lives and amount of property, and among its minor advantages will give Calcutta telegraphic intelligence of the shipping from Saugor Island.

Mr. Chapman has drawn the attention of the Bengal Government to the fact that the supply of water over many parts of Bengal has permanently diminished. He fears that local inquiry will show this to be the case in a degree highly injurious to agriculture, and tending to famines. He strongly recommends Government to consider Sir Arthur Cotton's scheme for a canal from Rajmehal to Calcutta, by a weir across the Ganges. He ascribes much of the evil to the growing subdivision of property, "undoubtedly one of the greatest drawbacks to all material and social progress." The denudation of forests has greatly increased the risk of famine, and to the deterioration in the quality as well as quantity of water much of the epidemic fever, which has wasted lower Bengal for years, is considered to be due.

A NEW KIND OF STEEL.

(From our own Correspondent.)

THE progress of steel-manufacture is becoming more and more rapid every day. We have to record invention after invention in this important branch of manufactures, in which discoveries follow each other in such rapid succession that practice has hardly time to put the merits of one invention to a preliminary test before another equally promising and interesting novelty makes its appearance. Since the invention of the Bessemer process, which has inaugurated this new era in metallurgy, we have had the inventions of cyanogen steel, titanic steel, and chrome steel, by Mr. Robert Mushet; we have the Martin process, the Siemens process, Mr. Parry's patent, and the Richardson process. Of all these, few only have as yet had the chance of a practical test on a commercial scale, and some are still in their infancy. The number of these recent inventions has been again enlarged by a new method of making steel, invented by Mr. J. P. Smith, the secretary of the Institution of Engineers in Scotland, at Glasgow. Mr. Smith has not as yet taken out the provisional protection for his invention, and he therefore does not name the substances employed by him in his process; but the method, or *rationale* of his invention can be understood without a knowledge of the precise name of the chemicals employed. The process commences with pig iron, which is melted in an air-furnace, in the cupola, or in a crucible. After fusion a certain percentage of the chemicals is added to the liquid mass, and the result is an almost instantaneous separation of the carbon from the pig iron, the new addition taking the place of the carbon in the iron, and the carbon appearing at the surface of the liquid metal in the form of graphite, which can be skimmed off and removed if the surface of the metal is kept sufficiently quiet. Mr. Smith, who is now working on a practical scale in a small foundry in Glasgow, has collected very fine samples of such graphite, skimmed off the surface of his liquid metal. Graphite is produced both from grey and from white iron—a fact which seems to indicate that the admixture is capable of removing combined as well as uncombined carbon, and of throwing it out in the form of graphite. Mr. Smith has not yet ascertained whether any percentage of carbon is left combined with the iron after this decarburisation, but some analyses of the products of his process are now in progress. From the tests made by Mr. Smith, it appears that the percentage of combined carbon in the product, if any, must be exceedingly small. A further addition made to the liquid mass, after removing the graphite, throws out the silicon in a similar manner. The silicon comes to the surface combined with one atom of oxygen as oxide of silicon, a white, dry, combustible powder, which is insoluble in water and in sulphuric or nitric acid. The appearance of this mass is very strange. It forms minute crystals loosely adhering to each other, and arranged in numerous superposed layers like so many thin skins thrown out in succession upon the surface of the liquid metal. The oxide of silicon obtained in this form is very pure, and it has been used by Professor Anderson, of Glasgow, for the preparation of silicic acid, or pure silica, with

great success. Mr. Smith has a considerable quantity of this curious material in his possession which he has collected from the steel so far produced. It is remarkable that, by this mode of treatment, the carbon is removed from the iron before the silicon, while in all processes, which refine the pig iron by oxidation, the silicon is the first to be driven off. The substances added to the iron take the place of those removed, and the product is therefore not exactly the same thing which would be comprised under the present definition of steel, if such a definition can be maintained and adhered to. The new product is a kind of steel in which the constituent carbon is replaced by another material. In appearance, this steel looks like very hard Bessemer steel made from iron which contains phosphorus. The grain is very close, and the crystals are arranged in groups with their axes in different directions. They reflect the light accordingly, giving to the fracture the appearance of alternating bright and dark spots. The metal melts at a higher temperature than cast iron, but at a lower degree than common steel. It can be cast with facility, and it makes no bubbles nor honeycombs. At a very dull red heat this material can be hammered, if carefully treated; but it is not malleable, and can be used only in the form of castings. The tensile strength is very considerable, but no sufficiently accurate tests have yet been made to give a precise figure for the breaking strength. Mr. Smith has produced a number of small bells from the metal. These are all cast from one pattern, and exactly alike in all dimensions; but the temper of the metal, or the percentage of admixture, is different in each bell, and, accordingly, each of these bells gives a different sound, making up a very wide range of keys or notes, without altering the scantling of the bells. The higher or lower tone of the bells is not accidentally produced, but is the result of the precise proportion of the mixture, and can be regulated at will. Although the temper or degree of hardness of the steel can be varied within a wide range, the character of the material always remains that of great hardness. It is superior in this respect to the hardest kinds of steel, and is, therefore, particularly suited for the manufacture of cutting-tools. Some trials made in this respect have given excellent results. The material is for this purpose cast into the form of square bars of the exact scantling required for the finished tool. Each tool is then ground to the approximate form without any previous hammering. After this the point of the tool is brought to a dull red heat, and dipped into water or oil. The cutting edge is then finished upon the grindstone, and the tool is ready for use. A considerable number of such tools is now in operation at the workshop of the Anderson Foundry Company in Glasgow, and the results obtained with this steel are very remarkable. The speed at which cast iron is turned in the lathe is from 30 to 36 ft. per minute, and soft wrought iron is turned at the rate of 50 to 60 ft. The same tool is employed for the roughing and for the finishing cut, and the tools generally work at this rate for a whole day without requiring to be sharpened.

THE BIRMINGHAM WIRE-GAUGE.

TO THE EDITOR OF ENGINEERING.

SIR,—A careful perusal of Mr. Latimer Clark's paper on the Birmingham wire-gauge, and of Mr. R. S. Culley's remarks in your edition of last week, prompts us to assist in further ventilating the question. Assuming Mr. Clark's tables to be correct, and believing the figures quoted in Mr. R. S. Culley's handbook, page 280, to represent the sizes of Messrs. Johnson's wire, we observe that in the numbers 1 to 22, which embrace nearly all the wire used in constructions, there is a perfect harmony in the sizes adopted by the largest wire-drawers in England, viz., Messrs. R. Johnson and Nephew, Messrs. Rylands Brothers (as extracted from the *Electrician*), and Mr. W. F. Henley; and it is probable that the same gauge is used by a number of manufacturers whose names have not been quoted, although it would have been useful if Mr. Clark had also given the dimensions of the wire produced by the leading Birmingham manufacturers, who may reasonably be supposed to be more closely identified with a gauge originated by their local predecessors. In our Westphalia Works we follow the exact sizes above referred to, in all orders given according to the Birmingham wire-gauge.

It would, therefore, seem that amongst practical men themselves there is not that difference of interpretation of numbers which could not be met by consolidating the Johnson-Rylands-Henley figures into the recognised B. W. G.

But unfortunately the numbers of that gauge do not suffice for present requirements. Most of the specifications of rope wire stipulate fractions of half and quarter numbers, with the additional precision of *full* or *bare*, and, therefore, in the useful numbers for ship rope, say from 10 to 20, we have already in daily practice forty different sizes for that wire alone.

In rising to the finer wire used for carding, weaving, &c., the difference of number represents pounds sterling per ton in value, and therefore here, as in the quarter-numbers of ship rope or the half numbers of telegraph wire, dimensions should be correctly defined. Makers and consumers must know the exact thickness represented by conventional numbers and vulgar fractions of numbers, and nothing more would appear to be necessary than to apportion a certain number of thousandths parts of a certain unit to a certain number on the Birmingham wire gauge.

The question is, who is to be the umpire as to the numbers, and what is to be the unit? The Birmingham gun-barrel gauge in numbers became obsolete with the introduction of arms of precision, the calibres of which required specifying to the thousandth part of an inch, or the now equally well understood decimal fractions of a metre.

There is no reason why worn-out B. W. G. should not also be allowed gradually to sink into an honoured grave. His happy release will give comfort to all those who have to deal with wire and sheets; and while the public mind is slowly ripening for the adoption of the metrical measure, let us simply accept the Johnson-Rylands-Henley numbers, apportion the diameter of the intermediate sizes, express their equivalent in thousandths of an inch, or, better still, in tenths of a millimetre, and thus pave the way for a denomination which everybody can understand and compare with a well-known standard.

The reform may at first entail some trouble with the working

wire-drawers, which, however, is of no practical importance, since ultimately it would tell in their favour by more closely defining the work done.

Yours truly,

HEINTZMANN AND ROCHUSSEN.

23, Abchurch-lane, King William-street, E.C., Oct., 8, 1867.

THE VARTRY WATERWORKS.

TO THE EDITOR OF ENGINEERING.

SIR,—It appears that one of the mains of the unfortunate Vartry Waterworks, erected for the supply of Dublin, has burst near the village of Newton Mount-Kennedy, and the escaping water has nearly drowned some of the inhabitants. Mr. James Andrews, the resident engineer of the works, accordingly writes a letter to Sir J. Gray, chairman of the waterworks committee, in which he states that the accident arose from an old crack in one of the pipes, which extended under pressure, so that the pipe finally gave way. Had Mr. Andrews stopped when he had stated this, there would have been no ground for animadversion. But he goes on to assert that "the pipe being thus defective, the contractor will be responsible for the damage." This opens a new view of a contractor's responsibilities, and one I feel satisfied no solvent contractor would be disposed to accept, since it is no part of his function to insure the parties for whom he works against the risks naturally pertaining to the prosecution of their business. If an engineer makes an engine for a steam-ship owner, and if the engine should break down, and the vessel be in consequence lost, would any one think of holding the contractor for the engine responsible for the consequences of the defect? And what is the difference in the principle, whether the article supplied is a steam-engine or a pipe? I do not know who the contractor for these works is; but the cool assurance with which Mr. James Andrews saddles him with the responsibility, which is neither obvious nor reasonable, raises a sentiment much more unfavourable to Mr. James Andrews himself than to the contractor. If it was the contractor's business to put in only sound pipes, it was equally Mr. James Andrews's business to see that none other were employed; and if from some oversight an unsound pipe was by chance admitted, why should the contractor, any more than Mr. James Andrews, be held responsible for the result? For aught the public can know, the pipes may have been too weak, and some one rather weaker than the rest may have been the first to give way, from too scientific a margin of strength having been allowed. But whatever the cause of the accident, the penalty of its consequences must necessarily be borne by the proprietors of the works, such accidents being one of the incidents of their business, and for which it is their duty to provide. If a railway axle breaks, and a train is damaged or destroyed, the consequences cannot be visited upon the maker of the axle, but have to be encountered by the railway company; and in like manner the Dublin corporation must be prepared to confront the consequences of the failure or injury of the Vartry pipes or embankments, however costly those consequences may be. A most uneasy feeling prevails throughout the whole valley of the Vartry in connexion with these works, and the people seem to live in continual dread of being overwhelmed by another Holmfirth catastrophe.

October 8, 1867.

AN ENGINEER.

THE MONITOR QUESTION.

TO THE EDITOR OF ENGINEERING.

SIR,—I do not think it necessary to expend many words upon the weak and wordy dissertation in praise of the Dunderberg, and in reprobation of the monitors which Mr. W. Watt, C.E., of Washington city, last week inflicted on your readers. Mr. Watt says that I have understated the thickness of the armour of the Dunderberg, and overstated the thickness of the armour of the Dictator. But even if the fact had been so, the circumstance could in no wise have affected the force of the argument I employed. This argument is that if armour is applied to ships to keep shot out, its thickness should be such as to be fully adequate to the realisation of the intended function, and that, with any given displacement, much thicker armour can be carried on the low sides of monitor vessels than it is possible to carry upon the tall sides of broadside ships where the metal has to be spread over a much larger surface. These doctrines are equally sound whatever the thicknesses of particular vessels may happen to be, and I am willing to admit, if it gives Mr. Watt any satisfaction, that the thickness of the armour of the Dunderberg is anything he thinks proper. If, moreover, he can find any engineer in this country willing to endorse his encomiums upon that vessel the eccentricity may be indulged without challenge from me—though I fear Mr. Watt's converts will not be numerous until he is able to produce intelligible warrant for his admiration. But with reference to the thickness of the sides of the Dictator I have only to repeat that the delineation you formerly gave of that vessel, showing a total thickness of iron of 10½ in. on the whole depth of the protected side, is the right thickness, and the alleged decrease of thickness in steps, which Mr. Watt specifies, is not correct. At all events, my measurements and the drawings you inserted were obtained from Ericsson himself, who is not only the author of the system, but was the contractor for the construction of this particular vessel, and your readers will have no difficulty in concluding whether he or Mr. W. Watt ought to know best how the vessel is built. It is no function of mine to proclaim the nature of Mr. Reed's faith regarding monitors, and I decline to be the medium for conveying to Mr. W. Watt this information. But in the discussion which took place at the Institution of Civil Engineers, when my paper on "Ships of War" was read, the leading engineers of this country who were there assembled heard Mr. Reed's exposition of his views on the monitor question, and saw his design for a new monitor with revolving turrets which he had pressed the Admiralty to adopt, since which time it is well known his recommendations have been sanctioned to some extent. In this country so completely has the opposition to the monitor system broken down, that there is now objection left without confutation, and I have retired from the field of controversy merely because in the residuum of prejudice that remains there is nothing presenting any stimulus of difficulty, and because, practically, the work of conversion to the monitor faith has been now virtually performed.

I am, &c.,

JOHN BOURNE.

October 8, 1867.

THE SOCIETY OF ENGINEERS.

W. H. LE FEUVRE, Esq., President, in the Chair.
October 7, 1867.

The Quality of Iron as now Used.
By EWING MATHEWSON.

THE title of this paper is somewhat indefinite, and, in itself, hardly perhaps, affords so sufficient an idea of its subject as could have been wished. It, however, opens a very wide field for discussion and remark; and if this be the result of its being read here, the object for which it was written will be gained.

The consideration of iron as a material or, rather, as the material with which all have to work must be interesting to civil and mechanical engineers alike, and any benefit that may accrue from information that is exchanged will be useful in almost all the many diverse paths of the profession whose members have their theories, calculations, and designs based upon certain data which they take for granted. Anything that may throw light upon or affect in any way the first elements in a train of reasoning is, all will agree, a matter of no small moment.

On introducing for consideration the subject of the quality or strength of iron, the writer may be deemed bold to venture on a topic that has been so ably and almost exhaustively treated by the most eminent engineers and men of science. Where Fairbairn and others have written so much and so ably, he might, indeed, be thought presumptuous who would put forward anything claiming to override or contradict what they have given. But there is in the present case no such intention, but rather an endeavour to show how far and in what manner the information that does exist is negligently used, sometimes misapplied, and often altogether ignored. It is probable that in this Society there are many members who, like the writer, are engaged as manufacturers, and practically deal with iron in some shape or other every day, and who are not professional engineers. To the latter gentlemen they look for the original designs from which to work; on them they wish to throw as much responsibility as they can; in their labours of originating and contriving they would wish to share as little as possible, and it is only incidentally, and by the way, that some of this designing work has to be done, though probably the necessity of it comes pretty often. But though wisely refraining from meddling in the province of the professional engineer, the manufacturer is an apt critic of his doings, and, having the advantage of seeing and working from the designs of many different men, is able to note the excellencies and peculiarities of their styles, and, by comparison, discover the points in which each is specially strong or faulty, and the engineer who, from professional etiquette, does not perhaps know how others may be using better methods than his own, often obtains from the manufacturer, not only information as to working details, but hints of improvements and ideas that have originated elsewhere. It is, then, one of the peculiarly good features of this Society that the two very different classes of men here meet together and contribute to a common fund of information and discussion. It is therefore to make some remarks on the qualities of iron as at present used in England, from a manufacturer's point of view, that this paper is written; and if for this reason engineering is spoken of, not only as a science, but as a trade, it may be pardoned if what is the custom at these meetings is thus in some degree overstepped.

In glancing for a moment at the history of iron-making in this country, certain proofs are found that it existed at the time, or even before the time, of the Romans invading England. It was, however, almost entirely in the southern part of the kingdom that this work was carried on, and it is in Sussex, Kent, and Gloucestershire that the most distinct traces are found. At the Norman Conquest the first-named county had almost a monopoly of the supply, and even at the beginning of the present century one furnace still existed in Sussex at a place called Dallington. It is curious to note that the same reasons decided on the locality for iron-making then as now, i.e., the close contiguity of the ironstone with the necessary fuel, then, of course, wood or charcoal; and as the quantity required was very great, it is probable that to this cause is owed the rapid destruction of the enormous forests that once covered the southern counties. In the Forest of Dean, in Gloucestershire, for many generations in later times, the ironstone cinder that had been discovered on the site of the old furnaces furnished ample material for the production of good pig iron. But with the continued and wasteful consumption of wood for fuel, and the consequent expense, iron-making languished instead of increased, and, incredible as it may now appear to those who see such boundless stores of mineral wealth, England only a hundred years ago was importing iron from North America at the rate of 4000 tons a year. It was in the beginning of the seventeenth century that Lord Dudley first attempted to use coal in his Staffordshire furnaces; but other manufacturers seem to have had little faith in the new fuel, for not till a century later was it adopted to any considerable extent, and this first occurred at the well-known furnaces of Coalbrookdale, in Shropshire. With the inventions of James Watt, and the general adoption of the improved steam engine for mining and all manufactures, iron-making received the final impetus that has continued to the present day, and which has given the staple and continuous supply of iron for every want and for every conceivable variety of application.

That good iron has always been made in England can hardly be doubted, and the finely finished armour and the elaborately wrought gates of the old days could only have been made from well worked iron. The revival of the iron trade may be said to have commenced about a hundred years ago, and it has since then been marked by two great events, which have probably had greater and more permanent effect on the prosperity of this country than anything since the invention of the steam-engine. The first of these was the invention of puddling by Cort in 1783, and the other the successful adoption of the hot blast in smelting by Neilson in 1829. For some time after the latter process came into operation, the iron produced by it, though more plentiful and cheaper, was manifestly inferior to the cold-blast iron. Still it saved to the country thousands of tons of what, but for it, would have been, as heretofore, thrown aside as worthless cinder; and although much prejudice has existed and still exists against the quality of hot-blast iron, yet now, by increased skill and attention in the manufacture, its inferiority in general strength and quality to cold blast is only about 3 per cent.

The most careful and elaborate experiments on the different

qualities and strengths of various irons have been made by Mr. Fairbairn, and although all engineers cannot perhaps agree with him in his deductions and in his theories for the application of his material, still his experiments are, as ascertained facts, most useful to all, and are generally acknowledged to represent truly what they profess to do. Taking these, then, first, it will be found that Mr. Fairbairn used for his tests of cast-iron bars 1 in. square, which he treated as girders 4 ft. 6 in. between their bearings; and with the load applied in the centre, the amount of breaking weight and the deflection under this transverse strain gave as fairly as possible the comparative strength and toughness of the different kinds. Having by this process tried upwards of fifty different samples of English, Scotch, and Welsh irons, he found that the breaking weight varied from 581 to 357 lb., and the deflection from 2.224 to 1.09. The average breaking weight here is 450 lb.; but taking from his list of irons the very bad ones, Fairbairn gives as a fair average 471 lb., and as the mean deflection 1.675 in. This confirmed the then ascertained and now acknowledged rule, that the breaking weight of a rectangular bar increases as the square of its depth, and he gives as his formula for calculating the ultimate strength of such bars of any size:

$$b = \text{breadth in inches,} \\ d = \text{depth in inches,} \\ l = \text{distance between supports in feet,} \\ S = \text{constant 471 (average);}$$

but S may be of course varied according to the quality of iron.
$$\frac{4.5 \times b d^2 \times S}{l} = \text{breaking weight.}$$

Put in slightly different ways, all the formulæ for this purpose are of the same character. Fairbairn's is adapted to the special length of bearing he used in his experiments. Molesworth takes rather a lower estimate of the strength of cast iron, and gives as his formula:

$$b = \text{breadth in inches,} \\ d = \text{depth in inches,} \\ l = \text{distance between bearings, in feet,} \\ W = \text{breaking weight, in cwt.,} \\ K = 18.$$

$$W = \frac{b d^2}{s} \times K,$$

which corresponds with 448 lb. on Fairbairn bar. There are many other formulæ used, but as they follow the rule that the breaking weight of the bar is as the square of the depth, the only difference between them is the value of the "constant," as in calculating the strength of any bar some given quality of iron must be assumed. It may be mentioned that a bar 1 in. square is not the best for making tests, as the size is so small that the slightest flaw tells to a large extent. Bars 1 in. wide and 2 in. deep are now generally used. However, taking Fairbairn's for the present purpose, there is now a convenient standard, by which may be measured the quality of iron for most purposes, most, not all, because there are special cases where great softness or intense hardness is desired, and they would not be represented fairly in the "girder" test now spoken of. In this paper, in comparing different qualities, numbers will be given, by which will be meant values of Mr. Fairbairn's S . Having thus enumerated (fairly, it is hoped) the data which may be worked from it is now to be seen how these are generally used at the present time, what are the standards of excellence exacted by engineers, and how far they are really enforced; and this leads to the principal propositions now offered, i.e.:

- 1st. That there are seldom any standards of excellence held up;
- 2nd. That standards when given are too low;
- 3rd. That when given they are often not duly exacted.

And first and principally with *cast iron*. The results of Fairbairn's tests have been seen; but it must be noted that as he was trying the different and proportionate value of the various brands of iron, each bar was necessarily made from one kind of pig. Now most present are aware of the fact that no one iron, however good and strong, is equal to what may be obtained by judicious mixtures; and, moreover, though this is hardly a corollary of the foregoing, average mixtures as generally used are superior to average irons taken alone. Twenty years ago Fairbairn stated this before a parliamentary committee; that is to say, every ironfounder, having his own theory of mixing (which he often hugs as a great secret), will generally have two or three kinds of iron in his yard, and mixes them to his liking. In London there is an advantage not obtained by country foundries, in the large quantity of scrap that is to be bought, and which forms a large ingredient in the iron used here, the only drawback being—and this is important sometimes—that no certain knowledge can be obtained of what quality is being melted. But the great bulk of cast-iron work made in England comes from the Midland Counties and the North, where great and many are the varieties known to the initiated. Some are far superior to the standards as yet mentioned, and very many are vastly inferior. And now let it be seen what engineers require. Well, generally they are most obliging, and require nothing in particular. Remember, cast iron only is being now spoken of. The only Government department that meddles in these matters is the Board of Trade; and among the regulations for railway construction it is demanded that in all cast-iron bridges there shall be a strength capable of sustaining three times the dead load and five times the moving load. But this, of course, leaves the design entirely to the engineer; and the Government inspector, in examining the drawings, doubles bases his calculations on some theory or formula as to the strength of iron, which may be much above or below what is actually used.

In what proportion of work is any strain mentioned at all? Of those in which any test is specified, there will be something to say presently, but generally there is a stereotyped phrase about "sound clean castings, free from all air-holes and other defects;" or, again, sometimes castings are to be of "good grey iron;" and these oracular conditions are copied from one specification to another so often that they become quite a tradition to all concerned. What is the result? The specification goes forth to the iron-founders and contractors, and tenders are requested. Now, the inner workings of a contractor's mind, while he is preparing his estimate, would be an interesting metaphysical study. Where do the marvellous tenders originate—

the marvellously low ones, and how can they be carried out? Can the mystery be solved? There is a great difference between the prices quoted if a large number are competing—an extremely large and surprising difference—and the lowest offer, if from a respectable firm is accepted. Now of the many different iron-men, three may be mentioned—the one who makes his own pig iron, an ironmaster, the founder who buys his pigs cheap, and the founder who buys his pigs good. In these days of free trade it is quite fair that the lowest bidder should succeed. Perhaps he is clever, and can manage his works economically; then he is entitled to the result of his cleverness. Maybe he is a man contented with small profits; then by all means let him be employed in preference to the greedy man, but let it be known surely, at any rate, that he is giving what is wanted. Now, the man who makes his own iron will naturally use his own pigs in preference to buying elsewhere, and, as seen already, no single iron, being as good as a mixture, his castings are presumably inferior, and though this alone may not be to a great extent, let it be remembered that there is an immense difference in the quality of ironstone; and not only may a single kind be used, but a single kind of poor quality. Moreover, he may, if the form of casting will allow it—and it sometimes does—run his metal direct from his smelting furnace into the mould, and this is manifestly inferior to iron recast in the usual way. The second man spoken of buys his iron, and chooses his market. It would be out of place here to name any special sort of iron, but all who know anything of the trade are aware that certain brands are cheap, decidedly cheap, varying from 10s. to 25s. per ton below the best prices. Now, these will produce castings of good appearance (this is a matter of moulding), but, as far as strength goes, they are notably deficient, and in some cases almost rotten, and the average of them would probably break at 350 lb. of dead weight, and most easily with a sudden shock. A rude test of pigs is to break them with a hammer, and it will be found that the inferior iron just mentioned will fly to pieces with a stroke or two from a small sledge, while the ordinary hammer necessary for the foundry-man is a heavy one of 20 lb. weight. It will probably be allowed that, if the foregoing facts are correct, these irons are not what any engineers present would like to employ in any constructions with which they may be concerned. It may perhaps be said to those who doubt, "where ignorance is bliss, 'tis folly to be wise;" for the irons are in the market, and are used for foundry purposes every day, and this is ever likely to be so, while in the rage for competition cheapness is the one and only cry.

But, it may be said, engineers do impose tests, "and do insist on them." These cases are most noteworthy exceptions to the general rule, and are worthy of imitation. Only in very large and important works is this done, and it may safely be affirmed that not in more than one case out of twenty is any test of breaking strain actually carried into effect with cast iron. But it may be said again, "This is not necessary; we always keep on the safe side in our calculation." This is most prudent, and it is hoped all do so; but surely in the present day it is too rough a rule with which to be satisfied. An engineer designs a girder to carry 20 tons, and by Fairbairn's formula calculates it would take 80 tons to break it. Really it would break at 60. The engineer is certainly safe, but he has a margin of 3 to 1, instead of 4 to 1, and if any sudden strain, shock or blow fall on his girder, it is less able to resist it. But it has followed in due course: the girders were made 10 per cent. too cheap, and they are 20 per cent. too weak, which is a very poor economy indeed. But the engineers who give and enforce tests, what of their practice? They make their designs and dimensions from certain data, and most properly see that these are true in practice. It has been seen that Fairbairn gives 471 as an average. The most eminent engineers generally take a scale of from 470 to 490. In a recent specification of Mr. Dempsey's, he gives as his test of quality a bar 3 ft. between bearings, 1 in. broad, and 2 in. deep, and this is to bear 26 cwt. in the centre without breaking. This taken by the standard thus,

$$\frac{4.5 \times 1 \times 2^2 \times 486}{8} = 2916 \text{ lb. (26.05 cwt.),}$$

gives 486 as expressing the quality required, as the bar with it just survives the 26 cwt. as demanded by the specification. In the specification for the New Mid and Railway terminus, Mr. Barlow gives as their gauge of strain; a bar 1 in. wide, 2 in. deep, and 4 ft. 6 in. between bearings, to carry 1800 lb. without breaking. This again gives

$$\frac{4.5 \times 1 \times 2 \times 450}{4.5} = 1800,$$

or a strain of only 450. This, however, was only for columns where cast iron is in its best form, and the test would serve to keep out iron that was quite unfit. Up to the present year no strain has been given exceeding 500 lb., so far as the writer can ascertain.

This point is now arrived at. Fairbairn's experiments with single specimens of pig iron have been quoted, and have been taken here as representing the average iron in the country. Molesworth's formula has been given rather below Fairbairn's in quality, but one which is probably used as much as any, especially by those who take all their data from books. It has been shown, also, how the first engineers use very nearly the same figures, and only just overstep the bare average of quality that can be obtained. It has been seen how necessary even these tests are to keep out the very inferior iron that is generally used with impunity in the great majority of cases where no tests are exacted. The different qualities have been identified by figures which range from 350 to 490; and taking 471 as the medium, it will be seen that although 471 was the fair average yet of the irons used, the bad ones go much further below the standard than the good ones go above it, thus showing that there is a tendency for poor qualities to be supplied where there is no supervision.

(To be continued.)

PROGRESS OF SHEFFIELD.—The population of Sheffield and the adjacent townships and the adjacent townships stood in 1821 at 65,275. In 1831 it had increased to 91,702; in 1841, to 110,891; in 1851, to 135,307; and in 1861, to 185,155. In 1865, it had further expanded to 207,261.

BRIDGE OVER THE RIVER LOIRE, NEAR CHALONNES; ANGERS AND NIORT RAILWAY.

M. DIDION AND M. MORANDIERE, ENGINEERS.

FIG. 1.



FIG. 2.

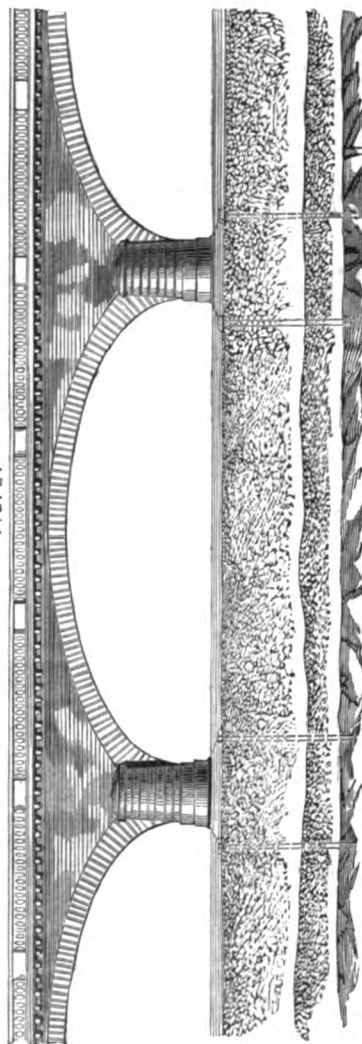


FIG. 3.

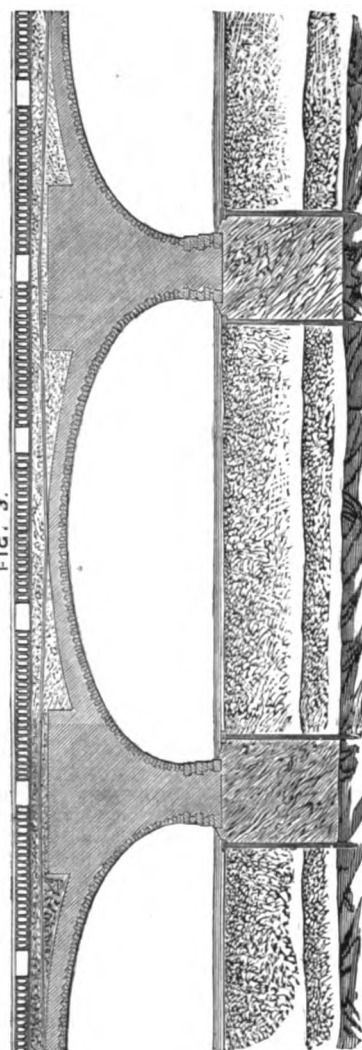


FIG. 4.

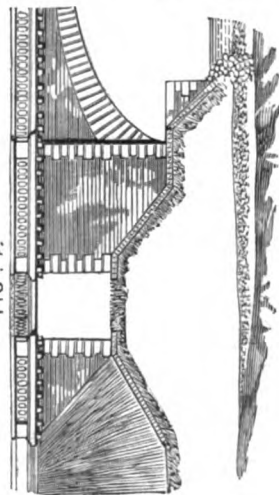


FIG. 5.

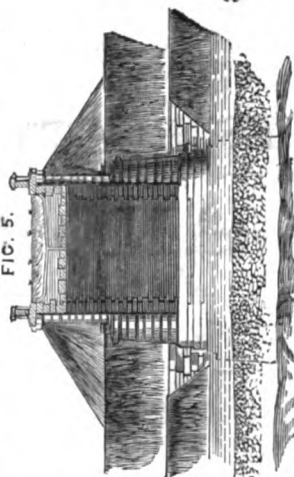


FIG. 6.

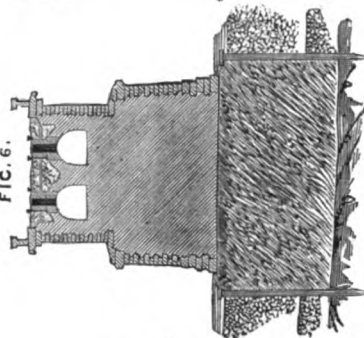


FIG. 7.

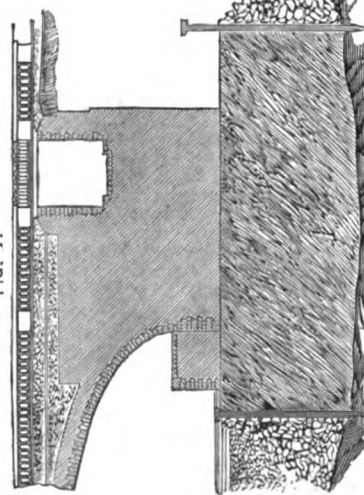


FIG. 8.

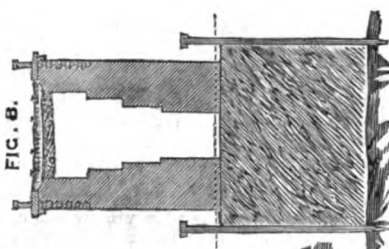


FIG. 9.



FIG. 10.



FIG. 11.



FIG. 12.



FIG. 13.

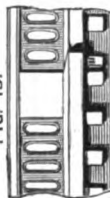
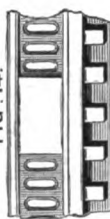


FIG. 14.



This bridge of which we annex engravings carries the Angers and Niort Railway—a line forming a portion of the system of the Paris and Orléans Company—across the river Loire about 2500 yards above the suspension-bridge at Chalonnès (Maine-et-Loire). It crosses the river at the point where the various arms of the latter unite, and it constitutes the finest masonry bridge which has up to the present time been constructed across the Loire. It is composed of seventeen openings, each of 30 metres (98 ft. 5 in.) span, and thus presents a total clear water-way of 510 metres, or a little over 1673 ft. The arches are of elliptical form, and the abutments are each provided with a small opening of 13 ft. 1 in. span to allow of the passage of the towing-paths. The bridge carries two lines of rails, and is 26 ft. 3 in. wide in the clear between parapets. The height of the rails above low-water level is 38 ft. 104 in. The work is entirely of masonry, with the exception of the iron girders over the small openings through which the towing-paths pass, and the total length of the bridge is 2018 ft.

Foundations.—The bed of the Loire, at the site of the

bridge, is composed of sand, more or less mixed with gravel at the lower part, and resting upon schist, and sandstone of the coal-bearing strata. Over a portion of the site, the surface of the rock is found nearly level, at a depth of from 12 ft. 3 in. to 15 ft. 3 in. below low-water mark; but near the middle of the river the surface falls rapidly, and the last piers have been founded in depths reaching to 28 ft. 5 in. at the sixteenth pier. This being the case, two distinct methods of putting in the foundations were adopted; those of the abutment on the right-hand bank of the river and the eight piers adjoining it having been put in by the aid of coffer-dams, whilst the eight remaining piers and the abutment of the left bank of the river were founded upon *bétons* submerged within enclosures of sheet piling. The foundations constructed by excavating within coffer-dams were generally put in with but little trouble, as the layer of gravel by which the rocks were covered was so coherent that it formed a water-tight strata, above which the coffer-dams had to be carried to but a small height. In the case of the eighth pier, however, some difficulties presented themselves, the strata

being more permeable, and the depth greater. The foundations, constructed of submerged *bétons*, were more costly and took a longer time to execute on account of the great depth of the excavation. The *bétons* blocks forming the foundation of the last eight piers are each 48 ft. 34 in. long by 21 ft. 4 in. wide, thus having a bearing area of 1028 square feet. The blocks are contained in caissons formed of main piles 12 in. square placed at a pitch of about 4 ft. 11 in. from centre to centre, the intervals between these main piles being filled in with smaller piles about 9½ in. square. The caissons are strengthened by stone heaped against them. The *bétons* which the blocks are formed is composed of broken stone mixed with hydraulic mortar, consisting of 5 parts (by measure) of powdered hydraulic lime from Doué or Paviers, and 9 parts of sand. Small coffer-dams were constructed around the upper parts of the caissons above the blocks of *bétons*, so as to enable the footings and lower courses of each pier to be easily laid dry.

The cost of the foundation of the sixteenth pier, which was founded at a depth of 28 ft. 5 in. below low-water

mark, or about 33 ft. below the average water level, was as follows:

Dredging (3110 cubic feet)	£
Caisson (142 ft. 4 in. run)	825
Concrete (313 cubic feet)	697
Heaped rubble around caissons (777 cub. ft.)	593
Miscellaneous expenses	400
	220
Total	£2824

The price per superficial metre of the block of *béton*, sunk at the depth of about 33 ft. below the mean water level, was 738 francs (297 l. 11s. 5d.), and the cost per cubic metre was consequently about 76 francs, or a little over 1s. 8d. per cubic foot. The cost of the caissons was 402 francs per metre run, or about 4 l. 17s. per foot run.

Method of Construction.—From the concrete to the springing of the arches, the piers are constructed of cut stone; but between the springings and plinths small materials only are used. Thus the string-courses, the corner-stones of the abut-

ments, and the cutwaters of the piers are simply constructed of picked rubble, and the voussoirs are of rustic-faced work. In order, however, to improve the appearance of the elevation, the small stones of which the voussoirs are really composed are cut so as to give the appearance of large blocks; and the same effect is also obtained in the case of the corner-stones of the piers. The employment of small materials in this way greatly facilitated the handling and laying of the stones, and also reduced the cost of the work.

The haunches of the arches are to some extent lightened by the formation in each of a pair of small longitudinal vaults 7 ft. 3 in. wide. These vaults have been introduced to reduce the amount of filling required between the spandril walls, and thus to reduce the thrust to which these latter are subjected. The lightening of the structure was not at all necessitated by the foundation, as the substrata does not carry a load of more than 4 kilogrammes per square centimetre, or about 8175 lb. per square foot.

The plinth of the bridge rests upon square dentils, and carries a parapet consisting partially of pierced work. The design of this parapet, which is simple and elegant, will be seen from the engravings.

Materials employed.—The footings and the piers, up to the level of low water, are constructed of cut stone and granite from the quarry of Bécon; the corner stones of the abutments, the cutwaters, and the voussoirs on the face of the arches are of limestone from Pernay, near Saint-Mars; the remaining voussoirs, and the face-work of the abutments between the corner stones are of rustic-faced stones from the same quarry; the rubble-work, employed for the interior, is of the schist of the neighbourhood; whilst the plinths and parapets are of oolitic limestone from Chauvigny, near Poitiers.

The lime was obtained from the kilns of Paviers and Doué, and, for the greater part of the masonry, the mortar was simply composed of 5 parts of powdered lime and 9 parts of sand, the same as for the *béton* of the foundations. Sometimes, however, to accelerate the setting of the mortar in the upper parts of the arches constructed during the bad season, there was substituted for one part of lime an equal quantity of Portland cement, this mortar being thus composed of 1 part of cement, 4 parts of lime, and 9 parts of sand. This mixture was found to give very satisfactory results.

Centres.—The centres were fixed so that each rested upon five points of support, two of these points being formed by the footings of the piers, and the three others by rows of piles, a double row of piles being driven in the centre of each opening. The wood employed in the construction of the centres of each arch amounted to 859 cubic feet for the lagging-boards, &c., and 6099 cubic feet for the main framework, making 6958 cubic feet in all. Nine centres were constructed for nine arches out of the sixteen, and these centres were used over again for the other arches. The cost of each of the nine centres averaged £204.

These centres were found to answer their purpose well; their deflection at the centre during the construction of the arches averaged 1.57 in. The settlement of the arches, after the centres were struck, averaged 1.96 in.

Time occupied in the Execution of the Work.—The work was contracted for on the 24th of April, 1863, and in the course of the remainder of that year the foundations of the abutments on the right-hand bank and those of the seven first piers were constructed. In the course of 1864 the foundations were completed, and eleven of the arches constructed, whilst in 1865 the last six arches were built, and the work finished. The time occupied in the construction of the bridge was thus about thirty months.

Cost.—A summary of the cost of construction of the bridge is given in the following table:

Nature of the Work.	Actual Cost.	
	Total.	Per foot run.
	£	£
Foundations	32,896	16.7
Masonry below the plinths...	32,718	16.5
Plinths and parapets	5,668	2.8
Centres	8,096	4.1
Miscellaneous	6,084	3.2
Total	£85,440	£43.3

The superficial area of the elevation comprised between the extremities of the abutments, the water-level, and the level of the rails is 76,396 square feet, and the cost per square foot of elevation has thus been about 11.2s. 6d.

The work was planned and executed under the general direction of M. Didon, Inspector-General of Ponts et Chaussées, and general representative of the administrative council of the Paris and Orleans Railway Company; and of M. Morandière, Engineer-in-chief of Ponts-et-Chaussées, and director of the new works on the western section of the company's lines.

The engineers in charge of the work were M. Croizette Desnoyers, Engineer-in-chief of Ponts et Chaussées and chief engineer of the company's lines in Bretagne and Vendée; M. Moreau, Engineer of Ponts et Chaussées, and the engineer of the company, who prepared the plans; and M. Dubreil, Engineer of Ponts et Chaussées, who had actually charge of the works.

The chief of that section of the Paris and Orleans Company's lines upon which the bridge is situated was M. Violet, Conducteur of Ponts et Chaussées; and, finally, the contractor for the work was M. Porrichon.

The railway bridge of Chalonnais, which we have described, is represented at the Paris Exhibition by a model and by a drawing of its details, this model and drawing being exhibited by the Department of Public Works of France.

RAILWAY ENTERPRISE IN HUNGARY.—M. Langrand Dumoucau, a Belgian financier of some eminence, has brought forward a scheme for an Austro-Hungarian Railway, from Kaschau to Oderberg, with a branch from Abos to Eperies. The length of the lines proposed to be carried out is 228 miles. Belgium will no doubt supply the rails and plant required.

THE STEAMSHIP "AUSTRALIAN."

THE fine steamship *Australian*, another addition to the West India and Pacific Steamship Company's fleet, recently built at West Hartlepool, by Messrs. Pill, Spence, and Co., sailed from Liverpool on the 15th inst. on her first voyage to the West Indies, carrying a large cargo and a full complement of passengers; her ports of destination being Port-au-Prince, Kingston, Vera Cruz, and Tampico.

The dimensions of the *Australian* are 324 ft. 6 in. long by 39 ft. 4 in. beam, and 26 ft. 6 in. deep, registering gross 2498 tons. She is brig-rigged, but without any bowsprit, having an upright stem, the plan usually adopted by her owners. This vessel has been built under the inspection of Lloyd's surveyor from the company's specifications, and under the superintendence of Captain Tweedie; great care has been taken to insure strength, and at the same time to obtain buoyancy, steel having been largely introduced into the upper fastenings. A deck-house is carried fore and aft amidships, in the centre of which is the saloon, very neatly decorated and panelled with inlaid woods. Aft of this there are first-class state-rooms for 62 passengers, which are particularly light, well ventilated, and unusually large.

The engines, constructed by Messrs. Blair and Co., limited, of Stockton-on-Tees, and designed by M. George Y. Blair, their managing director, have inverted cylinders, direct-acting, 58 in. diameter and 4 ft. stroke. They are fitted with surface-condensers, containing the large surface of 3600 square feet, and are also made to work with the common jet injection, if required.

The vacuum maintained is 27 in. The pair of engines has only one air-pump and one circulating pump, each 30 in. diameter, and 2 ft. 8 in. stroke, of which the parts are duplicate. When working as a jet-condenser, the circulating pump becomes an air-pump. The stroke of the pump is not observable on the discharge of the circulating water, which is a continuous steady flow, and is not greater than the amount of water from the discharge-pipe of an ordinary jet-condensing engine.

The water is discharged through the tubes of the surface-condenser.

The crank-shaft is 13 in. diameter at journals, and is in two pieces, with bolted flanges in the centre, made so as to be interchangeable in case of accident to the after crank.

We draw attention to the length of stroke of these engines 4 ft.; this is believed to be the longest stroke in any screw-engines of near this size. The two engines, made by Messrs. Napier, for the French Transatlantic Company, had the same stroke, but for 84 in. cylinders.

Economy is sought to be obtained by working expansively by separate valves, cutting off at from 6 in. to 24 in., which, together with a high speed of piston, and working with steam of 30 lb. pressure, gives the advantages of compound engines. The propeller is four-bladed, with very narrow surfaces, only 2 ft. 8 in. in broadest part, diameter 17 ft., and pitch 26 ft., causing little or no vibration to the vessel.

On the trial-trip the engines averaged from forty-seven to fifty revolutions, and gave a speed of twelve and a half knots to the vessel. The starting-gear is fitted with a steam-cylinder, and is easily under the control of one person. She is also supplied with Weir's marine governor. The boilers, four in number, with three furnaces each, 3 ft. 1 in. width of grate, bars in one length, 5 ft. long, cast in pairs, giving an abundant supply of steam, are constructed to work with steam of 30 lb. pressure, which is well dried in a separate steam-chest, and there is an entire absence of priming.

The feed-water is heated by the exhaust steam. Tubes of boilers are 7 ft. by 3 in. outside; there are seventy to each furnace, and separate combustion chambers.

The arrangements for the machinery were carried out most successfully by Mr. William C. Lang, the company's superintendent engineer. The aim kept in view in the construction of the engines has been simplicity and fewness of parts, combined with more than ordinary strength.

Every care has been taken to guard against contingencies, viz., the engine-room is separated from the stoke-hole by a water-tight bulkhead, thus avoiding the risk of this large space filling altogether with water, and, in addition to large engine and donkey-pumps, which draw through accessible mud-boxes and cocks all in sight and above the floors, there are four 8 in. ship-pumps, attached to the steam-winch—the method adopted in all this company's steamers.

There is also a means provided for letting steam into any of the holds either for extinguishing fire or for clearing the bilge-pipes.

The consumption is about 30 tons of Welsh coal per day. This is an estimate based upon the performance of her sister ship, the *Columbian*, and on the result of a four days' trial trip from Hartlepool to the Mersey. On this consumption the speed of the vessel will be ten knots per hour on the average of the whole voyage.

FROM THE NORTH.—Messrs. Wigham Richardson and Co. have completed a large order for iron buoys, for the London Trinity House, and they are completing a powerful tug for the Commissioners of Northern Lights. Messrs. C. Mitchell and Co. have completed a steamer of 1000 tons, named the *Capella*, which will trade with passengers and goods between London and Hamburg. Messrs. Hepple have contracted with the River Tyne Commissioners to build a new floating ferry for Shields.

DEATH OF SIGNOR BONELLI.—The death is announced of Signor Bonelli, ex-director of telegraphs in Piedmont. Signor Bonelli was a most active promoter of telegraphic communication in Italy, and he was known abroad by various discoveries in the science of telegraphy.

AUSTRALIAN GOLD.—The value of the Australian gold imported, to August 31st this year, was 3,277,818L. For the whole of 1866 the corresponding total was 6,889,674L; for the whole of 1865, 5,051,170L; for the whole of 1864, 2,656,971L; for the whole of 1863, 5,995,368L; for the whole of 1862, 6,704,753L; for the whole of 1861, 6,831,225L; and for the whole of 1860, 6,719,007L.

MR. JOHN A. ROEBLING.

JOHN A. ROEBLING, the engineer, whose portrait we published in our last number, was born on the 12th of June, 1806, in the city of Mühlhausen, in Thuringia, Prussia. After the usual academical education, he visited the Royal Polytechnic School at Berlin, receiving the degree of Civil Engineer upon the completion of his studies; this obliged him to remain three years in the service of the state, most of the time being spent in the superintendence of public works in Westphalia.

Emigrating to the United States in 1831, he settled in the neighbourhood of Pittsburgh, in Western Pennsylvania, almost the frontier region of the far west at that time, purchased a tract of wild lands, and devoted himself for several years to reclaiming it and building up a small country town. The life of a farmer proving rather monotonous to one educated for an engineer, he embraced the first opportunity which offered to enter again upon the pursuits of his profession.

Extensive canal and slack-water improvements were then in progress in most of the States of the Union, and he obtained his first situation in America as assistant-engineer on the slack-water navigation of the Beaver river, a tributary of the Ohio; this was followed by an engagement on the Sandy and Beaver Canal, a work intended to connect the waters of Lake Erie with the Ohio river, but never completed, both from lack of means and from the opposing influence of the rising era of railways. The last employment on works of this kind was on the Upper Alleghany river, where he located a feeder for the Pennsylvania State Canal. The time had now passed by for building canals, and railways were the order of the day. Entering the service of the State of Pennsylvania, he was employed for three years in surveying and locating three lines of railway across the Alleghany mountains, from Harrisburgh to Pittsburgh, the road being ultimately built by the Pennsylvania Central Railway Company, not a state enterprise.

A short period of rest from public works was devoted to commencing the manufacture of wire rope, a business in which he was the pioneer in America, and occupies the first place to this day. The introduction of these ropes on the inclined planes of the old portage railroad, on which the canal boats of the Pennsylvania State Canal were transported across the Alleghany mountain-range, was attended by the usual opposition incident to the introduction of anything new, and necessitated the rebuilding of the machinery by him on a style adopted to wire rope.

It was in this manufacture that the necessary experience was gained in regard to the nature and qualities of wire, and the practical application and handling of the material, an experience soon to be brought into play in the construction of the first suspension aqueduct in the United States.

The general idea of suspension bridges had been a favourite one with him ever since the college days, when it formed the subject of the graduating thesis; a suitable opportunity was merely wanting to carry them out in reality.

This was offered in the year 1844 at Pittsburgh. The wooden aqueduct of the Pennsylvania Canal, across the Alleghany river, having become so unsafe as to require its removal and the erection of a new structure on the old piers, the time being limited to nine months, including the winter season of 1844-45. The work was let by contract to the lowest bidder, who proved to be Mr. Roebbling. It was carried to a successful completion by him within the time specified, and opened to commerce in May, 1845.

This aqueduct comprised seven spans of 162 ft. each, consisting of a wooden trunk to hold the water, and supported by a continuous wire cable on each side, of 7 in. diameter.

A rigorous winter and an unusually rapid river added greatly to the difficulties to be overcome, heightened as they were by the entire novelty of the method of construction, and by the unavoidable imperfections of hitherto untried cable machinery, intended for the first time to make a large cable in the place in the place it was to occupy permanently.

One satisfactory phase, however, in the history of that work, and indeed of a subsequent one also, was the practical refutation its success afforded to the numerous attacks of the engineering profession of that day, who scouted at the bare idea of a suspension aqueduct, and predicted its downfall as soon as the water was let into it.

Following the building of the aqueduct came the erection of the Monongahela Suspension Bridge at Pittsburgh, on the piers of the old wooden bridge destroyed by the great fire of 1844; it connects that city with the borough of Sligo, and consists of eight

spans of 188 ft. each, supported by two 4½ in. cables, which in this instance were made on land separately for each span, and then hoisted in place from flatboats. In this bridge the pendulum principle was applied to counterbalance adjoining spans under the action of unequal loads.

In 1848, Mr. Roebling undertook the construction of a series of four suspension aqueducts on the line of the Delaware and Hudson Canal, connecting the anthracite coal regions of Pennsylvania with the tide-water of the Hudson river; they were all completed in the course of two years, as follows:

Lackawaxen aqueduct,	2 spans of 115 ft. each, & two 7 in. cables
Delaware	" 4 " 134 " " 8 " "
High Falls	" 1 " 145 " " 8½ " "
Neversink	" 1 " 170 " " 9½ " "

They are all essentially permanent works, as merely the woodwork of the trunk requires occasional renewal.

During this period Mr. Roebling removed from the west, establishing his works and his residence at Trenton, in the state of New Jersey.

Public attention had for some time past been directed to the problem of connecting the New York Central and Great Western Railway of Canada by bridging the chasm of the Niagara river, a problem which, from the nature of the locality, admitted of no other solution than by a railway suspension bridge. A company had been formed several years for that purpose, and had selected Mr. Ellet for their engineer. Under his superintendence a temporary bridge was erected at the site for foot travel and light carriages; this was in use several years, being subsequently removed. When, however, the time arrived for commencing the main work, Mr. Ellet had become involved in personal difficulties with the company, and left them. Mr. Roebling was then invited to make plans and estimates for the bridge, and was at the same time appointed the engineer.

For four years, commencing with 1851, the work was continued without interruption even during the coldest Canada winters, until, in March of 1855, the first locomotive and train crossed a railway suspension bridge; and it may be safely said that up to the present day it is still the only example of the kind of any magnitude.

It is needless to enter into any details of construction here, as the structure is too well known; it will be sufficient to state that it has a clear span of 825 ft., is supported by four wire cables of 10 in. diameter each, and has two floors, the lower one devoted to vehicles and the upper one to the railway trucks; these two floors are connected by struts and diagonal tension rods, so that the superstructure forms, in fact, a continuous hollow girder stiff enough to support the action of a rolling load, the weight, however, being supported by the cables.

Simultaneous with the progress of the Niagara bridge, another railway suspension bridge was commenced by Mr. Roebling, in the state of Kentucky, across the Kentucky river, on the line of the southern railroad leading from Cincinnati to Chattanooga. The gorge of the Kentucky river is both deeper and wider than that of the Niagara, requiring a clear span of no less than 1224 ft. The anchorages and stone towers were rapidly completed, and the necessary plates and saddles hoisted on the towers; most of the cable wire was delivered, as also the material for the superstructure, the girder principle adopted here being essentially different from that carried out in the Niagara bridge, no floor for vehicles being required in this case, when suddenly the finances of the railway company collapsed, and the bridge, as well as the railway, were abandoned for the time being. At this day the massive towers stand like monuments in the wilderness, places of pilgrimage from the neighbouring settlements.

In the fall of 1856 the foundations of the towers of the Ohio bridge, at Cincinnati, were laid; work was resumed the next year, and then interrupted for want of means.

With the further history of this now completed work, the readers of this journal are familiar, through the report which has recently appeared in its pages.

In the mean time arrangements were made to proceed with the erection of still another suspension bridge at Pittsburgh, to take the place of the old wooden Alleghany bridge, built in 1818, and now no longer safe. The removal of the old structure and construction of the new permanent work, including the building of three new piers and two anchorages, required three years from 1858 to 1860 inclusive. The total length of this bridge is 1030 ft., divided into two spans, of 344 ft. each, and two side spans, of 171 ft. each. The floor has a width of 40 ft., includ-

ing two side-walks, 10 ft. wide. The framework of the superstructure is composed essentially of iron girders, with a flooring of wood. Ornamental open towers of cast iron support the cables, which are four in number, two of 7 in. diameter, attached to the floor between the side-walks and carriage-way, and two of 4 in. diameter, attached to the ends of the floor-beams; in addition to the cables, there is an effective system of stays.

This bridge being completed, all enterprise was stopped for a couple of years by the outbreak of the civil war. In 1863, however, operations were resumed on the work at Cincinnati, and the bridge finally finished in 1867.

As regards the future works of Mr. Roebling, it may be mentioned that the reports, plans, and estimates of the New York and Brooklyn bridge, across the East river, have been matured during the present year; that with a clear span of 1600 ft., besides the approaches, it will cost about six millions of dollars, and that there is every prospect of enough capital being subscribed to enable operations to be commenced this winter.

SHIPBUILDING YARDS.

THE mechanical plant of a modern iron shipbuilding yard comprises machines of a very limited number of types. The operations to be performed in building an iron ship are virtually confined to bending, punching, and rivetting plates and angle-irons, and accordingly the whole plant of an iron shipbuilder consists of a repetition and multiplication of punching and shearing machines, of plate-bending rolls, and of machines for rivetting. There are some accessories, such as drilling machines, or plate-planing machines, to the application of which the refinement and high finish of the best class of work is due; but, even in the most advanced shipbuilding yards of the present day, these machines play a very unimportant part compared with the main bulk of the machinery. The punching and shearing machine used is the same as that employed by boiler makers; but there is, however, an addition made to it in the shipbuilding yard which boiler-makers cannot use to the same extent. This is the dividing-table, for advancing the plate to the machine at regular intervals, and by equal lengths or distances, so as to produce an equal and uniform pitch in each straight row of holes, without the necessity of previous marking and setting off. The movement of the dividing table is self-acting; the table is traversed upon a fixed bed by means of a correctly pitched rack advancing by the length corresponding to one tooth for each stroke of the punching slide. The plates to be punched are fixed to the table, and are passed in front of the punching-machine with an intermittent movement, advancing during the up stroke of the punch, and standing still while the punch descends and perforates the plate. Each stroke of the punching-machine makes one hole, or occasionally, when several punches are fitted to the slide, a corresponding number of holes are made at each stroke of the machine. A direct-acting, punching, and shearing machine has been invented by Mr. D. Cook, of Glasgow, and is now in use in several shipbuilding yards. This machine has no gearing, and is worked by a steam piston acting upon a lever which works the eccentric shaft carrying the punching slide. The steam cylinder is single-acting, and the weight of the piston pulls the punching slide back when the steam is allowed to escape from the cylinder. Mr. Cook's machine has the great advantage of moving only at the instant when the action of the punch is required, and standing still during the time in which the work is adjusted. For machines which cannot be worked with a dividing-table, as in making curved lines of rivet holes, or holes in irregular positions, such a machine is preferable to those of the common kind worked by gearing. It not only gives the workman any required length of time for adjusting the work, but it also allows of the stroke of the punch being reduced almost to the thickness of the plate only. The punch being always kept close to the plate, it is very easy for the workman to pace the latter in the precise position in which it is intended to be punched. The ordinary punching-machine, on the contrary, which gives a continuous and almost uniform movement to the punch, must be made so as to give a very long stroke to the punch itself, in order to allow the workman sufficient time for adjusting before the punch comes down upon the work. This time very often is too long, but occasionally it may be too short, causing the stroke to be missed, or, what is still worse, the hole to be inaccurately or improperly placed. Mr. Cook's punching-machine has the merit of avoiding

all these difficulties, and it also saves much wear and tear of gearing, belts, and other parts subject to deterioration in the common punching-machine. For bending plates, the well-known three-rolls are principally employed; they are usually placed two at the bottom and one at the top, between the two lower rolls. There are, however, some bending-machines which have two rollers placed vertically above each other, and a third in an adjustable position behind these two. A modification of these latter machines is used for producing sharp bends or corners in plates used for shipbuilding. The single roll is in this machine fixed in a movable frame, which enables the roll to be raised or lowered by means of a pinion gearing into a wheel segment. The plate is brought into the proper position between the front rolls, which latter are occasionally replaced by a simple slotted frame, and this suspended roll is then pressed down by means of the wheel segments which work the brackets carrying the roll. For bending bars and angle irons, a machine is employed similar to the machines used for straightening rails. The bars are placed upon two fixed props, and pressed down between these by a ram moving in a straight line. This bending-machine is by preference made horizontal, i. e., the ram moves in a horizontal line, which facilitates the handling of the long bars and angles operated upon. All this machinery is worked from the shafting of a shed generally placed parallel to the river frontage, and at a small distance behind the latter. Occasionally some machines are placed closer to the ships' sides in the open yard, and they are then made so as to be self-contained, with their engines attached, requiring only a steam pipe to be carried to them from the boilers. It is very remarkable that hydraulic machinery has not been applied to any extent for working shipbuilding implements. The whole appearance of a shipbuilding yard forces the idea upon the mind of an engineer that hydraulic pressure would be the most suitable means for transmitting power and effecting work. The punching-machines, the shears, and almost all bending-machines, have reciprocating movements, and require heavy pressures to be exerted upon their working parts. The production of all these motions by power transmitted through shafting-straps and cog-wheels causes an enormous loss of effect, and a very considerable wear and tear. In a large yard, moreover, the shafting must be carried along a very great distance to afford a sufficiency of working space between the different machines; the straps are in the way of the work as it is being moved about the yard; and sometimes several engines are required to avoid excessive lengths of shafting. These again require great length of steam pipes, causing a waste of steam. All this would be avoided by hydraulic machinery. An engine pumping into an accumulator such as is employed by Sir W. G. Armstrong, for working the cranes of large docks or warehouses, would give the necessary power; and water pipes carried below ground all over the yard would make it possible to start a machine at any particular spot, by making a simple connexion with the pipe nearest at hand. The machines for punching, shearing, and rivetting, if made on a plan somewhat similar to that of Mr. D. Cook, might be worked by water pressure with great advantage, and the same system would afford great facilities for managing and working cranes and other machinery employed in the yard. The experience gained in working hydraulic cranes shows that there are practically no difficulties in the application of this class of machinery, and that hydraulic pressure is an efficient, convenient, and reliable mode of transmitting power where it has to be distributed over a very large area, and where great strains are to be exerted. Up to the present time, hydraulic machinery has not been largely adopted by iron shipbuilders. The new shipbuilding yards on the Clyde are all made according to one type or model, with regard to their arrangement and selection of plant. Armour-plate bending-machines and some hydraulic lifting-jacks are the only machines using hydrostatic pressure which have come into favour with iron shipbuilders. There can be no doubt, however, that at some future time hydraulic machinery will be as largely employed in shipbuilding yards as it is at present used in docks and warehouses and in steel works; and it will afford similar advantages to shipbuilders to those which it has given to the steel-makers, who have learnt from Mr. Bessemer to apply hydraulic pressure to their converters, cranes, cogging-machines, rolls, and tyre mills.

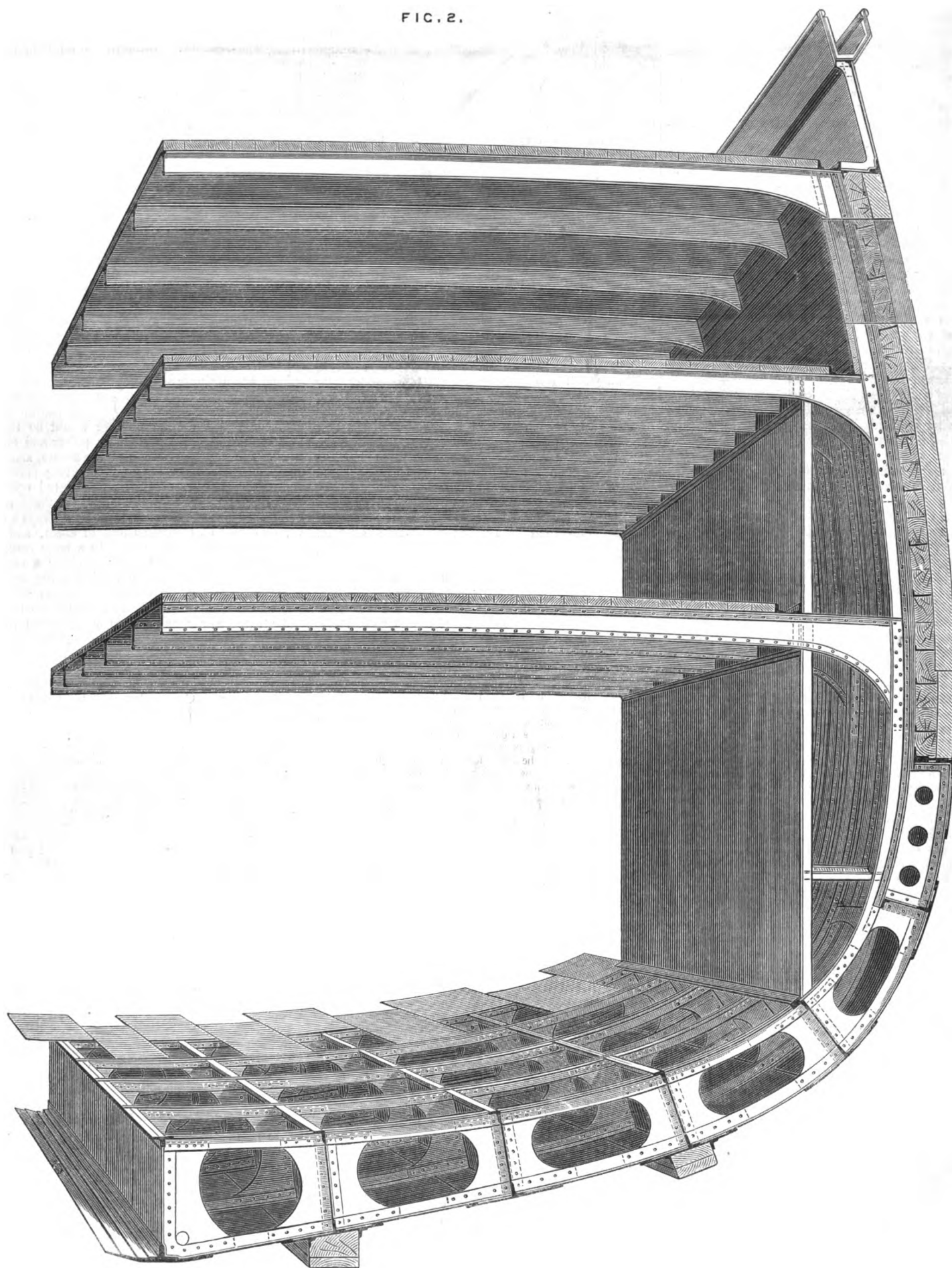
SHEFFIELD.—The iron trade of Sheffield and the district continues somewhat depressed. There is more activity shown with regard to steel, both for home use and for export, and there is some demand for steel rails. The armour-plate trade continues active, and sufficient orders have been received to keep the rollers at work until Christmas.

THE PRUSSIAN IRONCLAD FRIGATE "WILHELM I."

CONSTRUCTED, FROM THE DESIGNS OF MR. E. J. REED, BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

(For Description, see the opposite Page.)

FIG. 2.



THE PRUSSIAN IRONCLAD FRIGATE "WILHELM I."

CONSTRUCTED, FROM THE DESIGNS OF MR. E. J. REED, BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

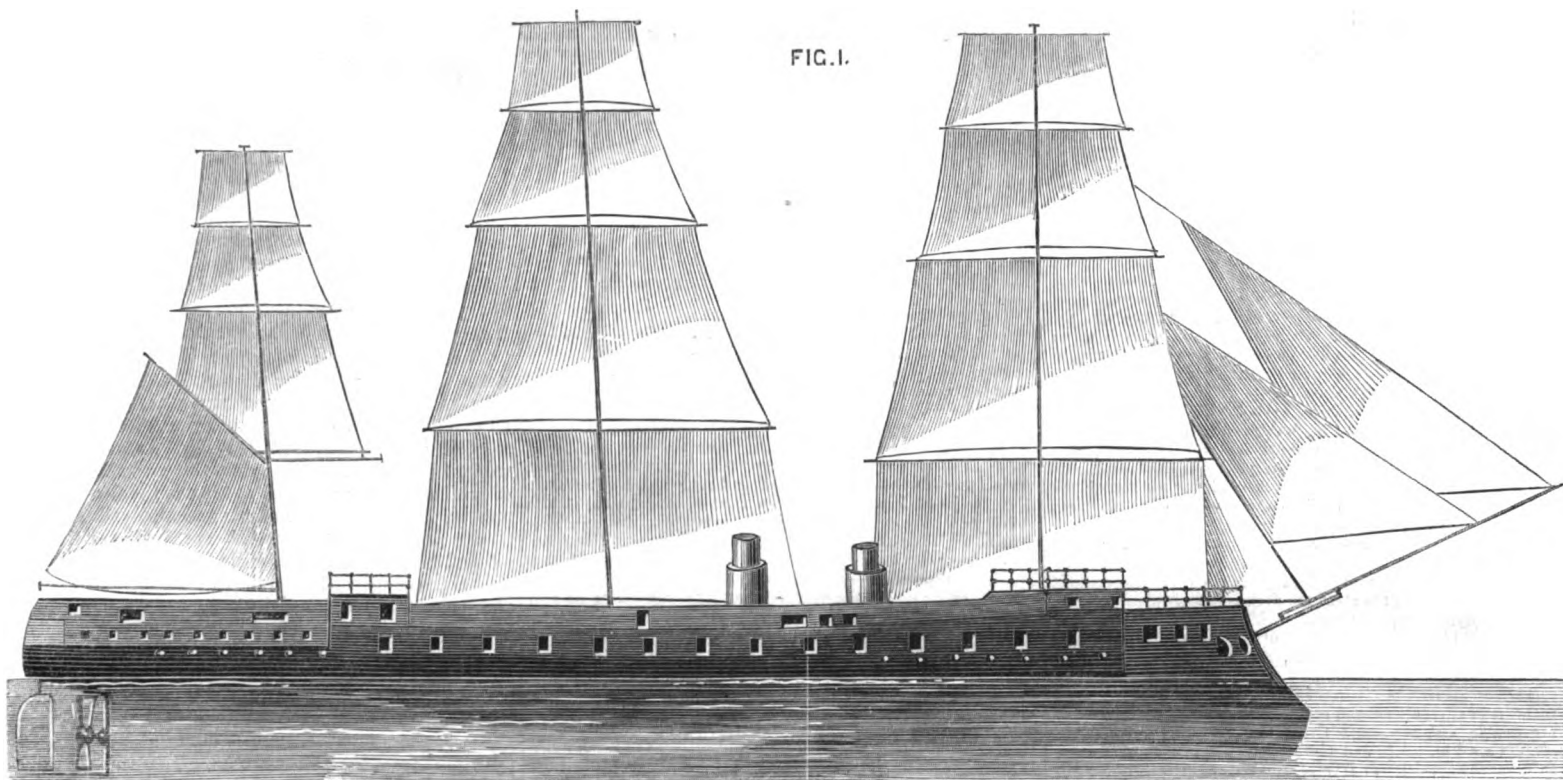


FIG. 1.

THE iron-built ironclad frigate Wilhelm I., of which we this week give illustrations, was designed for the Turkish Government under the name of the "Fatikh," but she has since been purchased for the Prussian navy. Her principal dimensions are as follows:

	ft.	in.
Length, extreme ...	372	4
" between the perpendiculars ...	355	10
" of keel for tonnage ...	310	1½
Breadth, extreme ...	60	0
" for tonnage ...	60	0
Depth in hold ...	18	10½
Draught of water forward ...	24	6
" aft ...	26	6
Height of port-sill above water-line amidships ...	10	0
Burthen in tons, O.M. ...	595	8½

The ship was intended to carry thirty-three seven-ton guns, twenty-eight of which were placed in a protected battery which extends from 42 ft. abaft the fore perpendicular along a length of 232 ft. on the main deck; and of the remainder, four were placed behind armoured bulkheads on the upper deck, and one was protected by an armoured battery at the extreme after end of the main deck. This armament has, however, been modified since her purchase by the Prussian Government. The engines are of 1150 nominal horse power, and are intended to work up to an actual power six times greater, and the estimated speed at full power is 14½ to 15 knots. The engines, which are of the three-cylinder class, are being constructed by Messrs. Maudslay, Sons, and Field. The vessel is also to be fully rigged and equipped, so as to proceed under sail when required. The armour plating on the sides of the battery is 8 in. thick; that on the transverse bulkheads at its extremities is 6 in. and 5½ in., the greater thickness being used where the bulkheads are exposed to fore and aft fire; and that on the stern, which protects the right aft port, is 6 in. thick. The teak backing in all these parts is 10 in. thick, and there are, in addition, longitudinal girders, two thicknesses of skin plating, and vertical frames at intervals of 2 ft., which complete the framing of the target formed by the ship's side. The details of these arrangements will be described further on. The protection of the hull at the water-line is secured by an armour-belt, which rises to the height of the main deck on the after side of the battery, and to the lower deck on the fore side. The lower edge of armour is at a depth of 6 ft. 8 in. below the water-line amidships, and a little less forward; while at the counter it is brought considerably nearer the surface. The lower strake of plating in this belt is 7 in. thick amidships and 5 in. at the extremities, but all the other plates are 8 in. thick amidships, and taper to 6 in. at the bow and stern. The backing, &c., in wake of the armour-belt are similar to those before alluded to. The outline of the armour plating on the sides of the ship is shown in Fig. 1, above. The armoured bulkhead at the fore end of the battery runs down to the lower deck; and as the armour-belt is there only about 2 ft. above the water-line, the deck is protected from vertical fire by 2 in. plating worked on the beams, and by teak backing worked between the beams. By this arrangement, a considerable weight of armour is saved from that which would be required if the bow was plated up to the height of the main deck. The upper part of this bulkhead is continued up so as to form an armoured bulkhead, which protects two guns on the upper deck underneath a short fore-castle deck. Each of these guns can be trained at two ports, from one of which it can be fired in the line of keel, and from the other at an angle of 20° on the aft side of an athwartship line. On each side, therefore, these guns command a training of 110° from the line of keel. On account of the fore and aft fire being obtained, there are no topsides or fittings on the upper

deck before the bulkhead, the light portable guard rails and stanchions shown in Fig. 1 being fitted for convenience and safety under ordinary circumstances. The after bulkhead of the protected battery is not run up in a similar manner to the fore one; but on the upper deck just above the end of the battery there is an armoured half-tower on each side, which contains one gun that can be fought from two ports. One of these ports is on the broadside, and at it the extreme training forward is 30°. The port on the aft side of each half-tower allows the gun to be fired at an angle of 15° with the keel; but in order to do this without recessing the side, it is necessary that the tower should be built out over the ship's side about 4 ft. On the fore side of the half-tower the armour is pierced by look-out holes, which allows the tower to be used for conning the ship when in action. A light bridge is carried across the ship above the upper edge of the armoured side, as shown in Fig. 1. From the preceding remarks, it will be seen that each gun in the half-towers has a training in both ports of 105°, reckoning from 15° with the keel. The right-aft fire, which is not obtained by these arrangements, is secured by the stern chaser in the protected battery on the main deck. The bow is formed and supported so as to allow the ship to be used as a ram, and this, combined with the great steering power resulting from the adoption of a balanced rudder, would make her formidable in this respect. The general arrangements of the rudder are similar to those of the Bellerophon, in which ship they have stood the test of service with the most satisfactory results. The rudder-head is protected by the armour-plating on the stern, and arrangements are made for steering the ship during action by a wheel placed within the protected battery, just under the half-towers. The unprotected parts of the ship's sides are very lightly framed and plated. The space outside the battery on the after part of the main deck serves as officers' quarters; the crew live in the battery; and the fittings on the lower deck are similar to those of other large frigates.

This ship is constructed on the bracket-frame system first introduced in the Bellerophon, and, like her, has an inner skin which extends about two-thirds of the length, and rises to the height of the main deck on each side. The vertical part of this inside plating forms the wing-passage bulkhead on each side, and is stiffened by vertical angle iron bars, so that it forms a very strong longitudinal girder which resists the strains on the structure caused by the unequal distribution of weight and buoyancy, and the ship's motion in a seaway. Throughout the double bottom the framing may be regarded as a combination of the longitudinal and transverse systems; and it is in the arrangements of the latter that the bracket-frame system differs from that adopted in the Warrior and other ironclad frigates. The longitudinal frames in the Bellerophon and this ship are much deeper than the corresponding frames in the Warrior, and they are continued right forward to the stern in the latter ships instead of stopping at some distance abaft it, as in the Warrior. By this means the framing forward has been much simplified, and immense strength has been given to the bow in case the ship should be employed as a ram. The keel arrangements resemble those of the ironclads of the Royal Navy, and are illustrated by the perspective view of a part of the midship framing given in Fig. 2. The flat keel is formed of a double thickness of plates, and the vertical keel plate is 54 in. deep and ¾ in. thick, with double angle irons 6 in. × 6 in. × 1 in. on the lower edge. The whole of the work in the vertical keel is made water-tight, and it thus forms a central longitudinal division to the double bottom. The stern and stern-post are formed by solid forgings which are connected with the keel plates in a most efficient manner. As there is a balanced rudder, the after post is dispensed with. There are six longitudinal frames on each side of the ship, their depths varying from 46 in. to 16 in. The

upper longitudinal forms a shelf which receives the lower edge of armour and backing, and is strongly connected with the bottom plating and the skin plating behind armour by continuous angle irons. The other longitudinals are worked on projecting strakes of bottom plating, and attached to them by continuous angle irons on the outer edges, while their inner edges are secured to the inside plating by short angle irons worked between the transverse frames. The plates in the longitudinals are in one depth, and are worked in the longest procurable lengths, the butts being carefully fitted and strapped, and similar care is taken to connect the butts of the continuous angle irons on the outer edges of the longitudinals. The longitudinals are twisted so that they stand square to the bottom at any transverse section, and care is taken to arrange the bottom plating so as to prevent the longitudinals crossing any seam. The longitudinal frames at the foot of the wing passage bulkheads are made water-tight, and thus form longitudinal boundaries to the space covered by the plating on the inside of the frames and to the wing-passages. The compartments thus formed in the double bottom are further subdivided by transverse water-tight frames at intervals of about 20 ft., and each of these subdivisions has its own means of access, drainage, &c. The three longitudinals out from the keel on each side are not made water-tight, but are lightened by having large holes 2 ft. × 1 ft. cut in the centre of the spaces between the transverse frames, except in those spaces where a butt comes. No loss of strength is involved in this lightening, as care is taken to proportion the holes cut in such a manner as to leave the plates as strong at a cross section through the holes as at their weakest section. By means of the great depth of the plates in these frames, the longitudinal strength of the ship is much greater than that of an ordinary vessel, and the double bottom is made roomy, and easy of access for repairs, painting, &c. The great advantages of the latter arrangement in an iron structure are so universally recognised as to need no remark.

The transverse frames in the double bottom are 4 ft. apart, and are composed of continuous angle irons on the inner edges, which are continued across the keel and scarfed to the frames in the wake of the armour, of short frame angle irons 5½ in. × 4 in. × ¾ in. worked between the longitudinals to receive the rivets in the outside plating, of short angle irons 3½ in. × 3½ in. × ¾ in. worked on the longitudinals, and of ¾ in. bracket plates connecting all these angle irons. The form of these bracket plates is shown in Fig. 2. At intervals of 20 ft. solid plate frames are fitted between the longitudinals, and between the inner and outer bottoms, and worked water-tight. On these the frame angle irons are double, 8½ in. × 4 in. × ¾ in., and are worked staple fashion between the longitudinals. In this system of construction the transverse strength given by the framing just described, and by the transverse bulkheads, is distributed by means of the longitudinals, which are kept from buckling by the bracket frames, the latter also serving to secure the rigidity of the bottom plating, and prevent the working which is so destructive to the fastenings of an iron ship.

Before and abaft the double bottom the framing is similar to that in the double bottom, with the exceptions that the longitudinal plates are reduced in depth, that the angle irons on their inner edges are made continuous, that lightened plate frames are used instead of bracket frames, and that the dimensions of the frame and continuous transverse angle irons are reduced.

A special mode of framing is adopted at the stern to resist the strains resulting from the action of the screw, and to prevent the vibration so commonly experienced in ships with large engine power. It consists of a combination of transverse plate frames and continuous horizontal flats, the latter extending between the stern-post and the aftermost bulkhead, and strongly connecting them. This connexion is rendered stronger by the

wrought-iron tube, which takes the engineer's shaft-tube, being firmly secured to the post and bulkhead, and connected with the transverse plate frames by encircling rings of angle iron. The whole mass of the framing is thus rendered nearly rigid.

In wake of armour the framing is entirely transverse, and is formed of 10 in. $\times$ 8 in. $\times$ $\frac{1}{2}$ in. angle irons, with double angle irons 8 in. $\times$ 8 in. $\times$ $\frac{1}{2}$ in. on the outer edge. The spacing of the frames is 2 ft., and the alternate ones are ended at the longitudinal at the foot of the wing-passage bulkheads. Every other frame is scarfed to the continuous angle irons before alluded to, and thus a transverse connexion is made in the framing from gunwale to gunwale, at intervals of 4 ft. The scarfs and butts of the continuous transverse angle irons are carefully shifted on adjacent frames. It will be remarked in Fig. 2 that lightened plate frames are worked between the armour shelf and the longitudinal next below it. These frames are 2 ft. apart and $\frac{3}{4}$ in. thick. By their use, as well as by other means, provision is made to meet the vertical strains resulting from the immense weight of armour on the ship's sides.

The decks of this ship are very strongly framed and pillared. The beams to the upper and lower decks, and to the main deck outside the battery, are spaced 4 ft. apart, but throughout the battery they are 2 ft. apart. Under the batteries on the upper deck the beams are also worked on every frame, thus having a spacing of only 2 ft.; but as these batteries are short, there are only a few beams spaced so closely.

The upper deck is completely covered with plating, that over the midship battery being $\frac{1}{2}$ in. steel, and that before and abaft the battery $\frac{3}{4}$ in. steel. The main deck is entirely covered with $\frac{1}{2}$ in. iron plates. The whole of this plating is worked flush on the beams, the edge strips and butt straps being worked on the upper surface, and scored up into the wooden deck planking. On both the decks the outer edges of the plating are worked out to the skin plating, and strongly connected with it. On the lower deck a stringer plate is worked on the beam ends, and its fore ends are scarfed to the 2 in. plating on the lower deck beams forward. At the stern the deck is entirely plated over, as far forward as the stuffing-box bulkhead, and a water-tight compartment is thus formed. The butts of the stringers and deck plating are treble chain rivetted, and the edges of the latter are single rivetted.

The outside bottom plating of this ship is worked in the usual manner, in alternate sunken and projecting strakes. The edges are double and the butts treble chain rivetted. The lower strakes are 1 in. thick, and the upper ones gradually decrease to $\frac{3}{4}$ in. The thickness is also reduced a little towards the extremities of the ship. The fore part of the bottom plating is doubled for about 40 ft. from the stem, so as to take the wear of the cables, &c., and the after ends of the strakes of plating are chased into one another, so as to form one fair thickness up and down the sides of the stern-post.

In wake of armour there are two thicknesses of plating, each being formed of $\frac{3}{4}$ in. plates. The inner thickness has treble-chain rivetted butt straps, but the butts of the outer thickness are without straps, and are double rivetted to the inner thickness. The edges of both thicknesses are single rivetted, but only the outer thickness has edge strips. Longitudinal girders 10 in. $\times$ 3 in. $\times$ $\frac{1}{2}$ in., are worked outside this plating, and are so arranged as to have two girders in wake of each strake of armour, at about 1 ft. from the edges of the strake. The widths of the strakes of skin plating are also arranged so as to make the edge fastenings of the inner thickness work in as fastenings in the longitudinal girders. From what precedes, it will be seen that the target formed by the ship's side at the battery is made up of the following thicknesses of iron and wood: 8 in. armour, 10 in. teak lacing, with two longitudinal girders to every strake of armour, two thicknesses of $\frac{3}{4}$ in. plating, the whole being backed by 10 in. frames spaced 2 ft. apart.

The plating on the unprotected parts of the ship is $\frac{1}{2}$ in. thick, worked flush with single-rivetted edge strips and treble-rivetted butt straps on the inside. The framing to this part of the ship is composed of 7 in. $\times$ $\frac{1}{2}$ in. plates, with a single angle-iron 4 in. $\times$ 3 in. $\times$ $\frac{1}{2}$ in. on the outer edges spaced every 4 ft. along the side, directly over the alternate frames behind armour, and of angle-irons 4 in. $\times$ 3 in. $\times$ $\frac{1}{2}$ in. worked intermediate between these frames, so as to stiffen the plating. Feet are formed at the lower ends of these frames, and they are rivetted to the main deck plating abaft the battery and to the lower deck plating before it.

The double bottom previously described gives great safety to the ship in case she strikes the ground and has her inner plating penetrated, and still further strength and safety are obtained by dividing the interior of the ship into compartments bounded by transverse water-tight bulkheads. The plating in these bulkheads is carefully worked, stiffened, and made water-tight, its general thickness being $\frac{1}{2}$ in., and the stiffeners being formed of 4 in. $\times$ 3 in. $\times$ $\frac{1}{2}$ in. angle irons placed vertically, 30 in. apart. There are nine of these bulkheads in this ship, and they are arranged so as to enclose engine and boiler-rooms, magazines, &c., and to bound the double bottom. Within the limits of the double bottom these bulkheads are always brought on a water-tight frame, and partial bulkheads are fitted in the wing passages so as to form continuations of the main transverse bulkheads, and complete the water-tight divisions out to the outside plating. Outside the double bottom the bulkheads overlap the transverse frames, and are single rivetted to them. The upper edges of the bulkheads are connected with the plating on the main deck beams by double angle irons. At the boiler space, where the transverse strength of the decks is much reduced by the large hatchways required for getting in the boilers, the plating of the transverse bulkheads is increased in thickness to $\frac{3}{4}$ in., and there are two sets of stiffening bars worked on opposite sides of the plating. One of these sets is formed of 3 in. $\times$ 3 in. $\times$ $\frac{1}{2}$ in. angle irons placed vertically 4 ft. apart, and the other of T-irons, 4 in. $\times$ 2 in. $\times$ $\frac{1}{2}$ in., placed horizontally, and made to answer as horizontal edge strips to the plating.

Before and abaft the bulkheads which bound the double bottom, water-tight flats are worked below the lower deck, and serve both as platforms for store-rooms and as horizontal water-tight divisions to those parts of the hull, thus completing the double character of the bottom throughout the ship. Water-tight trunks, which extend up to the main deck, give admission

to the spaces below these flats, and at the same time would prevent the water from passing out on to the lower deck in case these spaces were filled. This is a patented improvement by Mr. Charles Lungley, and was adopted, by Mr. Lungley's permission, in the Bellerophon, by Mr. Reed, the Chief Constructor.

In addition to these water-tight divisions of the hull, the shaft passages, the passage between engines and boilers, and the bulkheads of the magazines, shell and spirit rooms, chain lockers, &c., are all made water-tight, and so additional safety is secured.

Water-tight doors, scuttles, man-holes, &c., are fitted in order to give access to and afford communication between the various compartments; and a very complete system of drainage, pumps, &c., is provided for all parts of the ship.

The Wilhelm I. is being built by the Thames Ironworks and Shipbuilding Company, and considerable progress has been lately made in her construction. She was designed by Mr. E. J. Reed, the Chief Constructor of the Navy, by the sanction of the late Board of the Admiralty, obtained, by the desire of his majesty, of the Sultan (for whom she was originally intended), through the intervention of his excellency M. Musurus, the Turkish Ambassador in England.

PUDSEY STRAM FIRE-ENGINE.—The new steam prize fire-engine, made by Messrs. Shand, Mason, and Co., of London, just purchased by the millowners of the Pudsey district, had a day's trial on Thursday last at several of the mills. To commence operations, an alarm of fire was given at the place where the engine is stationed; the engine was immediately drawn out and the fire lighted, and then drawn to the nearest mill, and in ten minutes from the time of alarm the water was playing on the assumed conflagration, the steam being got up rather sooner during traveling than when at rest and surrounded by a crowd. A single jet of 1 in. diameter was thrown over the top of the chimney; afterwards two jets were thrown over the top of the mill at the same time, one being $\frac{1}{2}$ in. diameter and the other $\frac{3}{4}$ in. After playing about an hour the fire was damped up, and preparation made for removal to another mill, with steam up ready. On arrival at the next mill, in four minutes, one jet was playing on the premises. Four mills were visited in this manner, with similar results. The average pressure of steam was 120 lb. per square inch, varying only 5 lb. or 10 lb. during the whole travel. The water-pressure was 100 lb. per square inch, and at this pressure projected the water over all the factories at which the engine was tried. The engine is easily drawn by two horses, carries ten men, and all hose, apparatus, &c.; is fitted to carry coals and water sufficient to keep steam up so as to reach a fire at ten miles distance, and be ready for work at once on arrival. —*Leeds Mercury.*

STEEL RAILS.—The *Scientific American* of a recent date contains the following:—"The New York and New Haven Railway Company are testing the steel rails in a section between Port Chester and Greenwich. The president of the road, Hon. W. D. Bishop, formerly Commissioner of Patents, is an energetic, practical man, and we shall look to him for a report on the subject which will be conclusive of its practicability. Mr. Bishop is the first railway president to adopt the plan of locating his office on wheels. His office is a neatly fitted car, and his headquarters may be truly said to be anywhere between New Haven and New York that his presence is required." From the wording of the above the reader would judge that the practicability of using steel rails had never been tested in this country. They have been used here for several years, and are found to be economical and practicable just in proportion to the quality of the rails. If the New Haven Company has secured good steel rails, they will wear well, and no doubt the report will so state; but if it has bought some of the cheap steel rails, a plenty of which can be found in our market, how shall the report be "conclusive"? If the president of the company is to be found only on his car somewhere between New York and New Haven, we think it will be rather annoying to those who have business to do with the executive head of the company. Not much of an improvement that. —*American Railway Times.*

THE RODMAN GUN.—The misplaced satire of the *Pall Mall Gazette* gives way to faint praise of the "interesting" results and "fine velocity" of the 15-in. gun. Its error regarding "racking" we corrected last week. The *Army and Navy Gazette* has from the first shown the greatest appreciation of the gun, and will be glad to see its original impressions (shaken for a moment by the misstatements of the *Standard*) now confirmed. ENGINEERING's brief comment is by far the keenest and most scientific paragraph on the subject which has yet appeared in England—it is a pity that it did not appear some months ago. The *Engineer* is in a deeper muddle than ever, as will be seen by the fact that, in a question of guns, it goes off to talk about what it has "always said" about British powder. We are not aware of anything which prevents "British powder" or any other from being used in the 15-in. gun, and this side issue certainly has nothing to do with the subject. The *Pall Mall Gazette*, we may add, which declared lately that "whatever the *Army and Navy Journal* may say," the charge of 100 lb. was not the proper one for the 15-in. gun, will now probably think otherwise. At Fort Monroe they never think, now-a-days, of using less, and had fired one gun a hundred times, with a hundred pounds each time. We understand from respectable authority that it is contemplated to raise the charge of the 15-in. gun in America from 100 to 120 lb. of powder. This would produce upwards of 1600 ft. velocity. —*Army and Navy Journal (New York).*

A 120-TON STEAM-HAMMER.—Mr. Krupp is about to construct at his works at Essen a single-acting steam-hammer far exceeding in size any now in existence. The designs for this hammer—which will have a head weighing 120 tons—have already been prepared, and the patterns are now in hand. At present the largest hammer at Mr. Krupp's enormous establishment is one with a 50-ton head, falling 9 ft. 6 in. This is a single-acting hammer—the only one, we believe, on the works, all the others being double acting. The smaller hammers have heads varying from 25 tons (a very respectable size) downwards. In addition to these Mr. Krupp has also some peculiar tilt-hammers, constructed some years ago, in use. In these hammers a steam-cylinder is placed between the head and fulcrum of the hammer, and the piston working in this cylinder is directly coupled to the hammer shaft by a connecting-rod.

THE HYDE PARK LOCOMOTIVE WORKS, GLASGOW.

It has been for a long time past considered highly desirable to produce interchangeable locomotive engines, i.e., locomotives the details of which are constructed and fitted with such a degree of precision that every single element or part of any one engine could be exchanged with a corresponding part of any other engine made from the same pattern, without requiring any readjustment or alteration. Even at this present moment, however, it is only in a few of our first-class locomotive shops that work is habitually carried out with the precision and accuracy necessary for obtaining the advantages of this interchangeability and a description of the system adopted for attaining this end in one of the largest locomotive works of this country, the well-known works of Messrs. Neilson and Co., in Glasgow, will therefore, we believe, have more than ordinary claims to the attention of our readers.

The Hyde Park Locomotive Works are an establishment of comparatively recent date, and they are fitted with modern machinery and plant. They cover an extensive area on a flat and level piece of ground adjoining the North British Railway, and connected with it by sidings. At present the works are capable of producing over one hundred locomotive engines per annum, and the number of hands employed is about twelve hundred. The works are laid out in two parallel rows of buildings, enclosing an extensive yard, the centre of which is occupied by a large shed, placed with its centre line at right angles to the position of the two rows of buildings. The central building, which is divided into two portions by a passage, forms a store and controlling-office for all work in progress, and a portion of it is appropriated for three boilers, which are there most suitably placed for supplying steam to the numerous engines distributed in different positions throughout the works. The row of workshops on one side of the central store is devoted to the first stages of manufacture from the raw materials; it contains the boiler-maker's and blacksmith's shop, and in a separate tract the pattern-maker's workshop, the coppersmith's and brassfounder's shop, and the foundry proper. The other parallel row of buildings contains the finishing department. The shop shafting is arranged in single lengths, running longitudinally through each of the bays containing machinery in motion, and each length of shafting is driven by a separate and independent engine. These engines are placed outside the buildings, each line of shafting being carried through a bearing in the wall, and having a fly-wheel and crank attached to its projecting end. By these means each engine is made to work the shafting direct, without any intervening gearing, and without the application of a double crank-shaft. The engines have all single cylinders placed vertically, and fixed against the walls; they are covered by a small projecting roof of sheet iron, and enclosed in a kind of box made in two parts, so as to be readily opened and closed by the attendant. There are eight engines of this kind all placed at the inside or central end wall of the corresponding shops, so as to be as close to the boiler-house as possible, and to avoid loss of steam power through extensive lengths of piping. Every single workshop, including even the pattern-maker's, boiler-maker's, and the grinder's shop, is provided with a large and heavy cast-iron surface-plate, divided all over its face, by means of lines drawn across it, into equal squares, and every article produced is squared and measured upon these plates, and subsequently examined in another department upon a similar and equally correct plate. To ensure that accuracy which will permit of an interchange of parts amongst each set of engines, no direct measuring of the work with rules or scales can be permitted, and every article must be finished to one set of templates made once for all from the drawings, or occasionally even from another set of templates, sent along with the drawings by the railway engineers who order the engines. There is at this present moment such a set of templates in hand at these works, sent by Mr. Richard Eaton, the locomotive superintendent of the Great Western Railway of Canada, and which belong to a set of new engines, which we expect to illustrate very shortly. The original templates are used only for making a set of working templates. The working templates are mostly of cast iron. They contain each hole to be produced in the article in its proper size and position, and these holes serve as guides for the drill, which must pass through them in executing its work. Similar templates are used in the shaping-machine, and for other tools in finishing the work to size; and any required number of pieces are made from

one template, without any reference or knowledge regarding the special engine to which these parts may be ultimately fitted. To insure this still further, a double system of numbering and marking the work is introduced, one number being the current number of locomotives made, the other representing the current number of types of locomotives; all engines made from the same patterns bearing the same class number. In those portions of the works which make and finish the details, the number of type is the only one marked upon the work; and this includes even the boiler-shop, where a number of firebox tube-plates, or door-plates, or other parts and portions of a boiler would be made and finished with every rivet-hole or bolt-hole, or hole for attaching pipes and other fittings in them, without any reference to the ultimate combination in which the accident will throw the different parts together to be finally united into one boiler. The individual number of the engine does not appear until the boiler and its attachments have become so far united that its different parts are no longer single and detached pieces, and by degrees as other parts of the mechanism are added to it in fitting up an engine, these latter also receive the mark of the individual engine for which they are selected or destined; but from the moment this selection has taken place, and the current number of the engine is stamped upon any part, no further adjustment of its size is permitted: it has passed out of the hands of the workman who finished it, and out of the shop where any inaccuracies could be corrected; so that it must be a perfect fit, or the necessity for rejecting it will show itself inevitably in case of any want of precision, which, under another system, could have been remedied by a certain amount of hand-work done by the fitters in putting the different parts together, and which would then form that slight but all important distinction between ordinary locomotive construction and the manufacture of interchangeable locomotive engines.

In following the work through the different shops through which it passes in its systematic progress of manufacture, we commence with the pattern-maker's and joiner's shops, placed together in one building, and fitted with a set of wood-working machinery, mostly made by Messrs. John McDowall and Sons, of Johnstone. This is the only shop which has an upper story or floor, all other workshops being on the level of the ground. The foundry has been added to the rest of the works at a later date. It is contrary to the usual practice of mechanical engineering works in Scotland to make their castings on the spot, as the numerous and well-fitted foundries in their neighbourhood generally afford greater facilities and a better economy in producing the work given out to them than can be easily obtained in a special foundry connected to the engineering works. In this instance, however, the question of quality of metal employed for casting locomotive cylinders has been the principal cause for deviating from the general habit, as experience has proved that the hardness and strength of the metal employed for casting these cylinders could not be sufficiently controlled or relied upon in a foundry which was not exclusively devoted to the work of this one establishment. The mixture of metal for casting locomotive cylinders at present employed at the Hyde Park Works is Pontypool or Blanaervon grey pig iron and white forge pigs made in Scotland. The metal is always melted twice in the cupola before being finally cast. The first melting is run out into a small pig-bed in the yard, so as to produce an uniform metal first of all, and the pigs so produced are melted a second time in the cupola for casting the cylinders and some other portions of the mechanism, the rest being all cast of soft foundry iron run direct from the melted Scotch pigs. The cupola is of comparatively small size, and can hold only about 2 tons of iron. It has been purposely arranged in this manner to prevent the founders from charging the common iron along with that used for the cylinders, and the present practice is to melt this latter metal first and charge the cupola with common iron while this is being tapped and employed for its proper purposes only. The foundry is fitted with swing cranes of wrought iron, and a small special crane is placed at one end of the foundry, where two core-drying stores are situated for the use of the core-moulder. The fan is driven by a small engine having its own boiler placed within the foundry, so as to make the latter self-contained and independent of the rest of the works.

The boiler-maker's shop consists of three parallel bays divided by rows of columns carrying the roof, and supporting the travelling cranes which traverse the whole length of this shop. The punching and shear-

ing machines, four in number, and of varying sizes, are placed in one row, the shearing side of one facing the punching side of the next machine, with a clear space between them sufficiently large for permitting a plate, which has been punched along its longitudinal seams, to be turned over endways to the other machine, and trimmed at its edges by the shears. The largest of these punching and shearing machines, one of Messrs. Yule and Co.'s make, and capable of punching plates up to 1½ in. in thickness, is used very successfully for cutting the frame-plates of locomotive engines. In this operation a square or rectangular punch is very successfully employed, instead of the ordinary round punches, and the straight lines cut out by it are much nearer to their finished state than could otherwise be the case. This machine makes from 18 to 20 strokes per minute, and, under the management of an exceptionally expert workman, frame-plates are cut at that rate with great speed and accuracy. The marks, to which the punching and shearing machines work, are all set out by a special set of men, who operate upon the large surface plate placed at one end of the boiler-shop. The templates, for marking the punched holes, are made of wrought iron, and holes are drilled into them of the exact size of a cylindrical centre punch, which is passed through each hole in making its mark. These marks again are controlled and corrected by straight lines drawn from the surface plate. The boiler-plates are all planed and squared on all their edges, and those parts which have flanges turned up have their edges planed square after this operation. The smoke-box, tube-plate and all other parts which form the front end of the cylindrical barrel are turned and bored so as to make a perfect mechanical fit, and it is therefore possible to place any special part upon the surface plate, and set the templates or scribers against it with perfect certainty and complete accuracy. The punching-machine has punches with pointed centres, which follow the centre marks set out for them, and this is a further assistance to accurate punching. The holes, after bending and joining the plates, actually coincide to such a nicety that they would almost reconcile us to punched boiler work, if such a reconciliation were possible upon any terms, now that drilled boiler plates and welded longitudinal seams have become a practical reality. The principal part of the work is machine-riveted, and hand-work comes only into use where the machine cannot be brought to act upon the rivets.

The forge or blacksmith's shop is one of the largest in existence anywhere. We expect to give the dimensions of all these different shops, their arrangement and relative position, at a future occasion, as these data can be better understood by reference to a representation of the ground-plan of the whole works. The steam-hammers of larger size are placed in one row, each between two furnaces, which carry boilers for utilising their waste heat in raising steam for these hammers. The several boilers are connected with each other so as not to make any one hammer dependent upon one furnace only for its supply of steam. The largest of these hammers, which has a 2½ ton head, is of a peculiar construction patented by Mr. D. Cook, of Glasgow. It has two cylinders, which carry the hammer-head between them, the two piston-rods being connected by a cast-iron cross-piece, to which the hammer is attached. A more modern hammer, and one which is very successful in practice, is that patented by Messrs. Neilson Brothers, and illustrated in the first volume of *ENGINEERING*, page 331. There are two of these radial hammers in use at these works, and they are particularly suitable for the different operations of making the parts of wrought-iron wheels. The system of stamping or forging between dies is carried out very largely in the forge; but no attempt has ever been made to stamp by hydraulic pressure, although Mr. Dubs, who formerly managed the works, is one of the first inventors of the hydraulic forging-press. All work delivered from the forge to the finishing shop passes through the central store, and to this are also delivered all the forgings and finished articles, such as steel crank-axles, injectors, and similar objects which are obtained from other establishments.

A very complete system of register and supervision has been introduced in this stove by Mr. Wilson, the present principal foreman of these works, which enables every one initiated to see at one glance which parts of any particular engine have been finished, and where any other parts are to be looked for in the particular workshops and in their different stages of progress. This register includes even the working drawings in the hands of the different foremen, and it prevents the possibility of these drawings being mis-

laid or lost in any one of the numerous shops through which they have to pass. The finishing department contains the usual large number of self-acting tools. These machines are so arranged in their succession as to reduce the labour of transporting the work as much as possible. The machinery for turning and boring the wheels, for shrinking on the tyres, and for fixing the wheels to their axles is all contained in a limited space set apart for it. The wheels, when fitted to their axles, are turned in their own bearings in a large double-wheel lathe by Messrs. Neilson Brothers, operating upon both wheels at the same time, and with four cutting tools acting simultaneously upon each wheel. A very ingenious and useful machine has been recently added to this plant. This is the invention of Mr. James Reed, one of the partners in the firm of Messrs. Neilson and Co., and its application is the boring of the crank pin-holes in the two driving wheels of a locomotive after the latter are fixed to their axle. In principle, this machine resembles the American quartering machine, illustrated and described in *ENGINEERING* some time ago, but Mr. Reed's machine is much simpler and less costly than the latter. We expect to give a complete drawing of this machine very shortly, and we therefore defer its description till then. The surface plates and the men employed in using them are of course still more numerous in this department than in any other workshop. Each piece of work is marked and set out for the machine tools by men specially trained for this kind of work, and the workmen at the different machines have nothing to do but to adjust their work so as to cut to the lines and points marked out for them. This is an imitation of a system carried out still further in some Continental locomotive shops. At the works of Graffenstaden, for instance, no workman is allowed to adjust or set his work upon the planing-machine, or to centre it in the lathe, &c., this being done by a special set of men who go from machine to machine, laying down the work in its proper position in each machine, and setting it right for the attendant, who has nothing to do but to keep his machine and tools up to the work as prepared for him by these superior workmen. Division of labour in this respect is very beneficial from many points of view, and it should be more generally adopted in this country. A special portion of the finishing-shop is occupied by the department for making the templates. This is considered the high school for "gentlemen apprentices" and other favoured "young hands" in the works; and there can be no doubt that the work in this department is likely to give a more ready and correct insight into the different branches of the work than any other special occupation. The work is of course not left to these inexperienced hands without the strictest control on the part of the expert men entrusted with the supervision of the template-making department.

The boilers and engines in progress of their fitting up are placed in two parallel rows, each engine facing one of the side doors of the building, so that it can be drawn out into the yard or painting-shop immediately after its being completed. There are sixteen such stands for engines in one row at the extreme end of this fitting-shop, and the parallel row behind this is capable of accommodating twenty boilers in their stage of progress. Each boiler is tested by water-pressure within the shop, and, before its being placed upon wheels, the pressure is maintained for a considerable length of time, so as to give ample opportunity for detecting and stopping any leaks. When completely fitted, each engine is tried by steam, and after this it is passed to the painting-shop, while all bright or polished parts are sent to the respective departments for being finally "got up" in all their surfaces.

We have still to notice the grinding-shop, with six large stones, in which we understand some of Ranson's patent grindstones are to be tried very shortly, and a new case-hardening furnace, consisting of two clay retorts, such as used by the gasworks, and which are employed instead of the ordinary muffles. In the coppersmith's workshop a hydraulic press is used for bending pipes, instead of the primitive drop-weight very often employed for this process. The dome-covers for many engines are now made of charcoal iron produced in Scotland, and this material has a sufficient ductility to allow of its being bulged out and worked cold into the distorted shapes required for the purpose.

The ensemble of these large and well-arranged works is an interesting and pleasing sight, and well adapted to create confidence in the high quality and excellence of the work produced with its efficient plant and under its well-considered system of management.

SLEEPING-CARRIAGE FOR THE NICOLAI RAILWAY.

CONSTRUCTED BY MESSRS. WINANS, AT THE ALEXANDROFFSKY WORKS, NEAR ST. PETERSBURG.

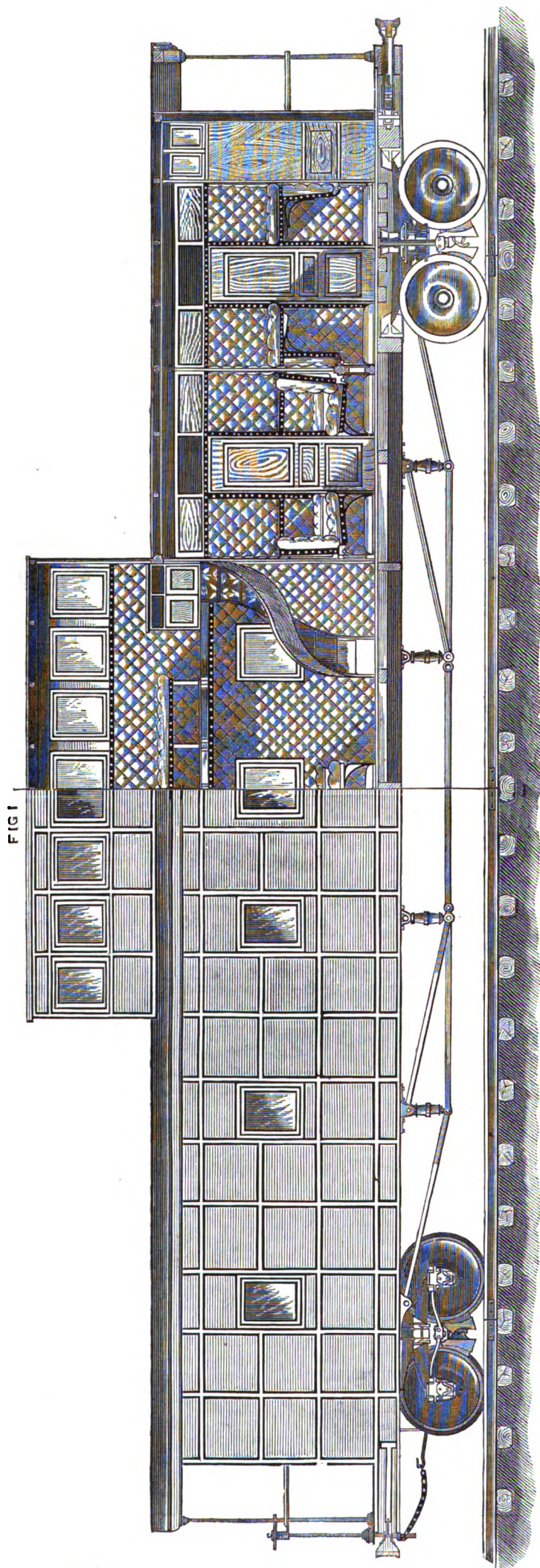
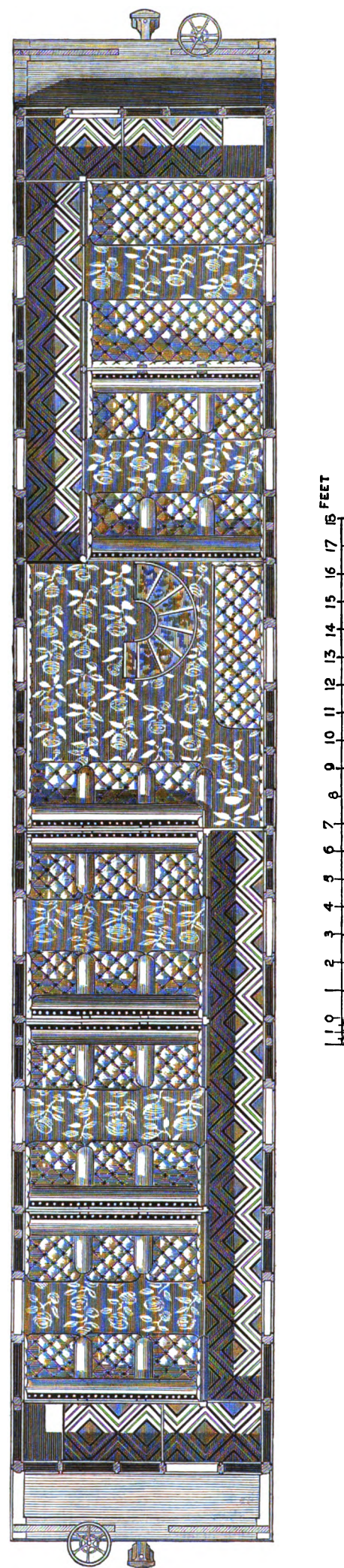
(For Description, see Page 369.)

FIG. 2



COAL RESOURCES OF INDIA.

(Continued from page 328.)

THE small but valuable coal-field of Kurhurbali is situated to the north of the Barakur river, and about 80 miles from the Luckiesera station of the East Indian Railway. It is very limited in extent, its greatest length not exceeding $6\frac{1}{2}$ miles, and its breadth nowhere being more than $2\frac{1}{2}$. The area of coal-yielding rocks altogether scarcely exceeds 10 square miles. In this field there are several beds of good coal of considerable thickness from 8 to 14 ft., and well placed for economical working. Much of this coal is also of better quality than the ordinary Indian coals, and therefore more valuable. Owing to the cost of transport, and other causes, the working of this coal-field ceased for the time in 1863, but on the completion of the chord-line from Raneeunge to Luckiesera this small field will again be opened.

The Jherria coal-field is extensive, though not very rich. It extends along the valley of the Damoodah river, commencing about 10 miles west of the most westerly part of the Raneeunge field. Its greatest length, from east to west, is about 21 miles, and its greatest breadth about 9 miles. It is traversed throughout all its length, and towards the southern limit of its area, by the Damoodah river. The total area may be taken as 200 square miles. Its geological structure is like the Raneeunge field, but it differs from it in the absence of any representatives of the overlying Panchet series.

The Bokaro coal-field commences not more than a mile to the west of the extreme westerly extremity of the Jherria field. From this it extends along the valley of the Damoodah and of the Bokaro rivers. It forms a long narrow band of coal-bearing rocks of more than 40 miles from east to west, with a breadth never exceeding $7\frac{1}{2}$ miles. The total area of the field is about 220 square miles. This field is comparatively not rich in coal, and much of what does occur is of inferior quality, and will be useful only for the ruder purposes of brick and lime burning.

The small detached coal-field of Ramghur occupies a triangular space along the valley of the Damoodah. It extends from the old town of Ramghur, where its breadth in a north and south direction is not more than a few hundred yards for about 12 miles, but at the eastern end it has expanded to a breadth of nearly 6 miles. The total area of the field is not 30 square miles. It is much cut up by faults and disturbances, presenting however, on the whole, the same general type of structure as the other coal-fields of Bengal, a series of beds dipping generally to the south, and cut off there by faults, which bring them into contact with the gneissose rocks of the vicinity. The beds of coal are not numerous, and, for the most part, are of inferior quality.

The Hoharo, or Karunpoora, coal-field is of large extent, covering a surface of at least 450 square miles. Close to, but detached from this field by a narrow belt of gneissose rocks, there is another, which may be conveniently called the South Karunpoora field; its limits occupy about 120 square miles. So far as is yet known, these extensive fields are very poor in coal, and what does occur is for the most part of inferior quality.

Near to Eetcoora, to the north-west of Hazareebagh, coal occurs of poor quality, but usable for burning brick or lime.

In Palamow some coal workings were for years carried on by the Bengal Coal Company, near the village of Rajhera, but they have now been abandoned for years. The actual limits of this field have not yet been determined. The strata appear to be a good deal disturbed and contorted, and the district to be poor in coal, and only calculated to be useful for supplying local demands.

Not far to the west of the village of Singhpur, the colliery of Kotah has for years been known, and has yielded a fair amount of coal of good quality. A cursory examination of the Singrowlie district proved the existence of coal of fair quality in eight or nine different localities, extending from Kotah, on the east, to Beryli on the south-west, and spreading over an area of about 40 miles in length from east to west, and 20 miles in breadth.

A very large area, extending along the Upper Sone, the Mahanuddy, and from thence down to Sohagpoor and the vicinity of Ummerkuntuk, has also been cursorily examined. The prospects of any large amount of coal being available from this district are not good. Some thin seams, apparently unworkable, were noted near the district of Bijragoogurb, and also near to Sohagpoor, further to the south, and near to Anoorpoor.

Near the village of Koorba, some 50 miles from the Mahanuddy, coal was noticed in the bed of the Hutsoo, so long since as 1840. Coal occurs in the Hutsoo near Koorba, in the Beeja Kurra, 25 miles north-east of Koorba, and in the Labeled, a few miles further on. It is said to extend about 200 yards along the bed of the former, and about a mile in the latter; coal was also found in the Chornai stream, a tributary of the Hutsoo.

There is but little coal in the Talcheer field, and that little poor in quality. The total area of the coal-bearing rocks in the field is not more than 10 square miles.

Along the southern side of the Nerbudda valley, coal rocks appear in several places extending from the vicinity of Jubbulpoor for miles down the river course. Near Mopani, the Nerbudda Coal and Iron Company have their works, which are likely to be heavily taxed as soon as the Great Indian Peninsula Railway is opened to Jubbulpoor; but hitherto, owing to the difficulties of carriage, but little coal has been sent away from the mines. The Mopani coal is very much of the same general character and quality as the coals of the Raneeunge field, in Bengal.

About 20 miles south-west from Hoshungabad is the most westerly point at which coal or the coal-yielding rocks have been noticed. From this westward to the coast of the Gulf of Cambay, the country has been examined in the hope that more favourably placed deposits might be discovered, more accessible from the sea-coast and from Bombay harbour; but no trace of these formations has been met with.

Near to Oomrait, and along the valley of the Pench river, beds of coal have been traced, which promise to be of much value. These occur in nine different places, where there are beds varying from 3 to 15 ft. in thickness; all these beds dip at angles nowhere exceeding 10 degrees, and are for the most part favourably placed for working. The field is 90 to 100 miles from Nagpoor, to reach which one range of ghauts has to be passed over.

Coal is also known to exist near Chanda, but the place has not been examined.

At or near Kota, on the Godavery, coal has been more than once reported; the specimens obtained some years since proved to be only thin papery laminæ of a jetty substance in earthy shale; the beds are often very thin; and even if in quantity, it will be worthless as a coal.

Several attempts have been made to work some thin seams of coal which occur in Cutch; but the coal, unfortunately, offers no hopes of proving valuable as any general source of fuel.

For many years there had been successive reports regarding the existence of coal near Kotree, in Sind; but the deposit, which had been partially worked, proved not to be a true bed, but an irregular accumulation, which did not extend a stone's throw in any direction from the pit which had been sunk.

Near to Kalabagh, on the Indus, and at several places along the southern face of the salt range to near the Jhelum, irregular seams of lignite have been traced. There is nowhere, however, in that area a prospect of any large supply of this so-called coal; and what is procurable is of very inferior quality.

Patches of coal or lignite have been found in several places along the outer range of the Himalaya mountains. In many cases these lignites have been of bright, clean, jetty substance, and burned well; but many of the pockets of this so-called coal have been entirely extracted, and have not yielded more than 40 lb. of the coal.

At the foot of the Darjeeling hills similar patches of lignite have been found; but they have all proved similar to those just noticed, namely, either detached fossilised stems of trees, imbedded in the sandstone, or nests of lignite of no extent. There are, however, evidences of the coal-bearing rocks occurring near to Punkabaree, at the foot of the Darjeeling hills; but their limits have not been traced, and no coal is as yet known to occur there.

In Assam several good coal seams have been discovered, and in many other cases indications of good coal occur. It is impossible at present to state over what extent of area these beds range; but it can, however, be unhesitatingly asserted that the amount is very large and most valuable. Assays of the Assam coal showed a proportion of ash not exceeding 2 to 5 per cent.

The occurrence of good coal in the Khasi hills has long been known; several efforts have been made to work the beds, but the great practical difficulty of bringing the coal to market rendered them all abortive. This difficulty arises from the fact that the coal beds occur at an elevation of nearly 4000 ft. above the adjoining plains, from which the hills rise with a nearly vertical scarp. The coal is of excellent quality, and is

specially well adapted for making gas, and it is also admirably suited for steamers, locomotives, &c. On the whole, it is remarkably free from iron pyrites, and if procurable in large quantities, at a fair rate, would be a most valuable fuel.

At the most westerly extremity of the same range of hills, where the country of the Garos overhangs the Brahmapootra, coal has been stated to occur in more places than one, but no specimens have yet been obtained. Similar statements have also been made of Cachar, but hitherto the only samples of coal obtained have been in small fragments, and with precisely the structure and character so markedly present in those specimens of fossilised stems previously alluded to. Similar specimens have also been sent from Chittagong; but nothing in any one of them would lead to the inference that any regular or continuous deposit of coal will be found. The same remark will also apply to Cheduba, Sandoway, &c.

In British Burmah no workable coal is known to occur; nests of coaly matter have been found, which have been exhausted before more than a few hundred-weights of coal were obtained. In Upper Burmah some irregular beds of inferior coal have been examined, but they hold out no prospect of supplying anything more than a very local and limited demand, and even this with inferior fuel.

In the Tenasserim Provinces beds of coal near Mergui were examined in 1854; but they hold out little prospect of affording a large supply, while the coal is of inferior quality. The imbedding rock has here, however, been much more highly mineralised, and forms a usable coal.

BRITISH ASSOCIATION.

ELECTRICAL STANDARDS.

At the recent meeting of the British Association at Dundee the Report of the Committee of Electrical Standards was presented by Mr. Fleeming Jenkin.—The committee report that considerable progress has been made during the past year, and that the principal instruments required by them have been completed, and are in use. The most important experiments have been those conducted by Dr. Joule, having for their object the determination of the mechanical equivalent of heat, by observing the heat generated in part of a voltaic circuit, the resistance of which was measured in absolute units by means of the standard of resistance issued by the committee. Last year preliminary experiments of the kind were made by Dr. Joule, and the agreement which he then reported between his mechanical equivalent obtained by frictional experiments and those obtained by the electrical method was so close as to lead to a suspicion that the results might be partly fortuitous. The experiments conducted this year with every possible care gave 779 as the value derived from the British Association standard of resistance, while 772 is the well-known number derived from friction. The details of the experiments were given in an appendix to the report. Dr. Joule expresses himself much pleased at the close agreement between the two numbers, and states his opinion that the electrical has been carried out with even fewer sources of error than the frictional method in assuming the B. A. standard to be an exact decimal multiple of the absolute unit. The last and most perfect series of experiments comprise thirty for the thermal effect of current in the spiral, thirty for the effect of radiation, and thirty for the horizontal intensity of the earth's magnetism. Dr. Joule expresses himself willing to make a new determination by friction. Meanwhile, the experiments already completed remove all fear of any serious error either in the number hitherto used as "Joule's equivalent," or in the Association standard: a fear which hitherto, remembering the very discrepant results obtained by others, has been very naturally entertained even by the sub-committee from whose experiments the standard was constructed. In connexion with the measurement of resistances, Mr. C. W. Siemens has invented a simple and excellent contrivance by which the measurement of resistances can be made by persons wholly unaccustomed to electrical experiments. They have only, after the necessary connexions are made, to turn a screw till a needle stands opposite a fiducial mark, when the resistance required may be read directly on a scale with considerable accuracy. Mr. Siemens proposes to apply this invention to thermometers, when the resistance read will indicate the temperature; and the only electrical connexions required will be the joining of the battery-wires to two terminals. Other applications of this invention will doubtless arise, and extend the practical application of electrical measurements. Mr. Siemens reports that in accuracy and range his instrument fully equals the Wheatstone bridge, whilst it possesses considerable advantages in cheapness and portability. Mr. Hockin has tested the constancy of the standard resistance units with satisfactory results, except in the case of one mercury tube, in which case he suggests that lead-glass may have been used, and injury have consequently taken place from the nitric acid used to clean it. Mr. Hockin has also made interesting experiments on the construction of large resistances by the use of selenium. He finds that coils can be made of this material having resistances of one million units and upwards, and that these artificial resistances will maintain their constant