

LOCOMOTIVE FOR THE FESTINIOG RAILWAY (2 FT. GAUGE).

DESIGNED AND CONSTRUCTED BY MESSRS. GEORGE ENGLAND AND CO., ENGINEERS, LONDON.

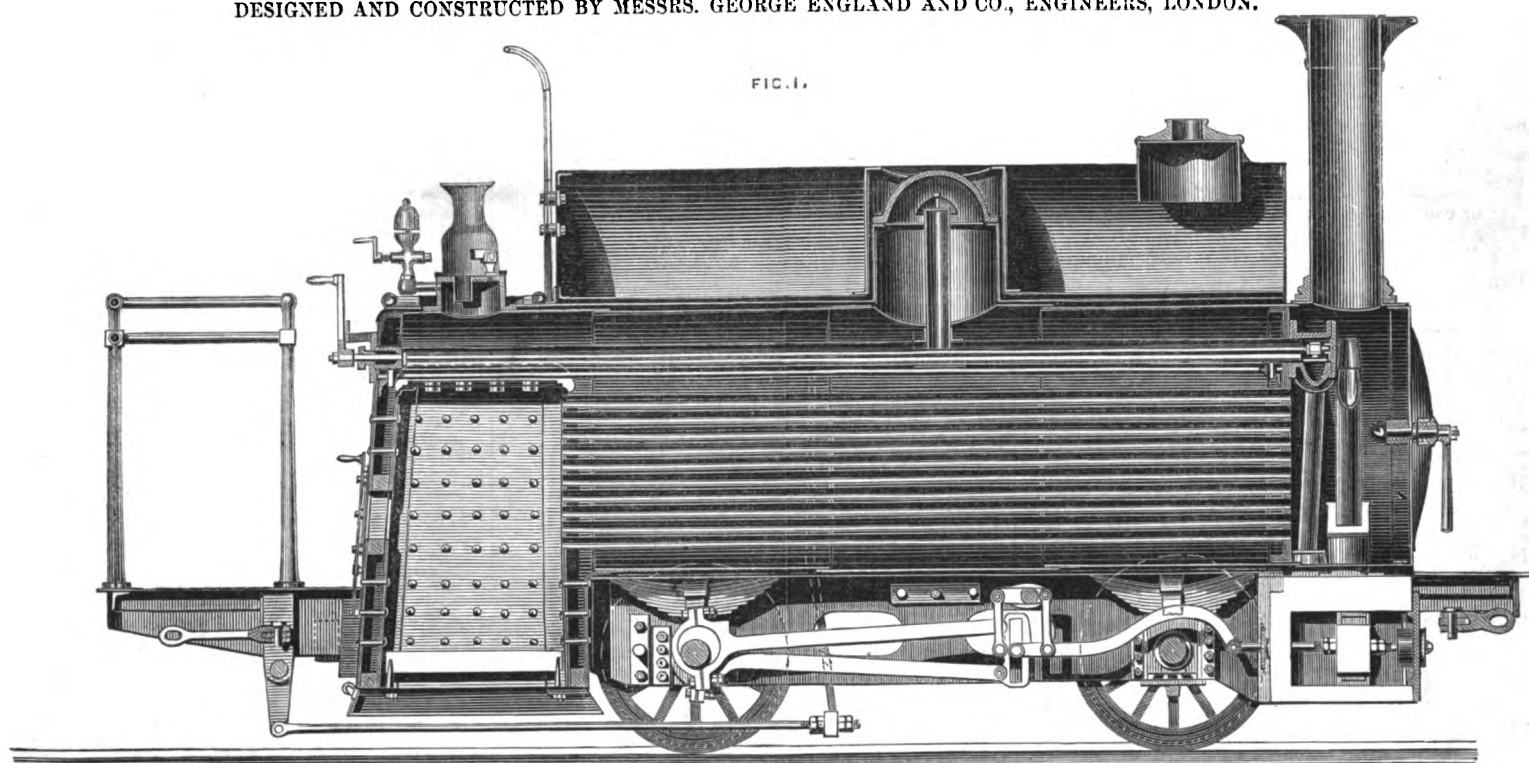
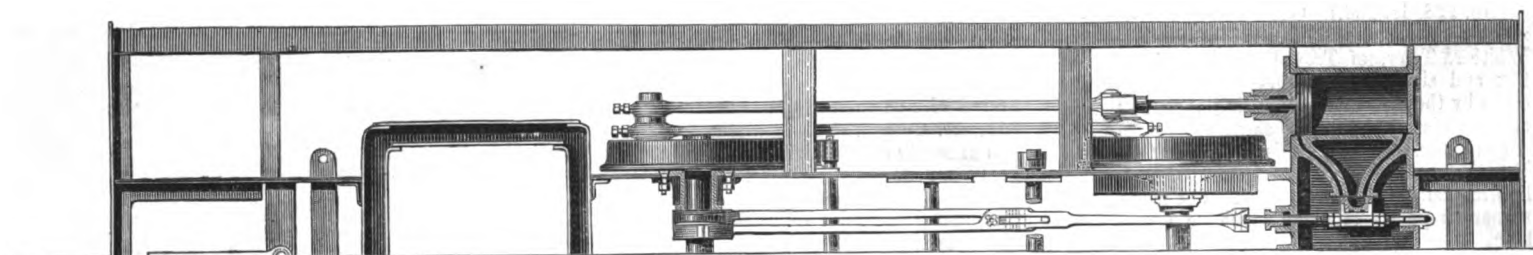


FIG. 2.



at a speed of from ten to fifteen miles per hour, is 50 tons this including the weights of the carriages and trucks, but exclusive of the engine and tender. They work five trains per day each way, and it is stated by Captain Tyler, the Government inspector, in his paper on the Festiniog Railway, read before the Institution of Civil Engineers, that, "in fact, the actual performance of the engines, exclusive of considerable shunting, is to convey daily on the up journey to Portmadoc, along the Traeth Mawr embankment, average loads of 260 tons of slate, all the empty slate trucks from Portmadoc, 50 tons of goods, and 100 passengers, besides parcels, at an expenditure of 17 cwt. of coal for two engines, or about 0.75 lb. per ton per mile, the average ascending gradient for 12½ miles being 1 in 92, and there being a level portion for about three-quarters of a mile near Portmadoc." In designing these engines, the centre of gravity has been kept as low as possible, and, notwithstanding their short wheel-base, not one has ever run off the rails during the four years they have been at work.

During the autumn of 1864 the company carried passengers experimentally without charge, and at the commencement of 1865 the line was regularly opened for passenger traffic. In the ascending journey from Portmadoc the trains were made up with the goods wagons next the engine and tender, the passenger carriages being placed between the goods wagons and the empty slate wagons. In descending, the empty goods wagons, together with the loaded slate wagons, are sent down first in a train by themselves, then follows the engine-tender first, and finally the passenger carriages are sent down detached from the engine, and at some little distance behind the latter. The passenger carriages are preceded by a brake van, with a guard standing on a platform outside it, and the speed is limited to about six miles per hour in passing round the sharpest curves, and to about ten miles per hour at other parts of the line.

The passenger-carriages are 10 ft. long by 6 ft. 3 in. high, and are 6 ft. 6 in. high above the rails in the centre. Each carriage is carried on four wheels 1 ft. 6 in. in diameter, the axles being placed 4 ft. apart from centre to centre. There is a longitudinal partition down the centre of each carriage, and the passengers sit back to back, so as to avoid overhanging weight as much as possible. Each carriage will convey ten passengers, and the classes do not differ from each other, except in the character of their fittings. They are provided with central buffers and couplings, and their cost is 100*l.* each for the second and third class carriages, and 120*l.* each for the first-class carriages.

The preliminary expenses incurred in adapting the Festiniog line for being worked by locomotive engines were considerable; but the change has been a great success, the saving

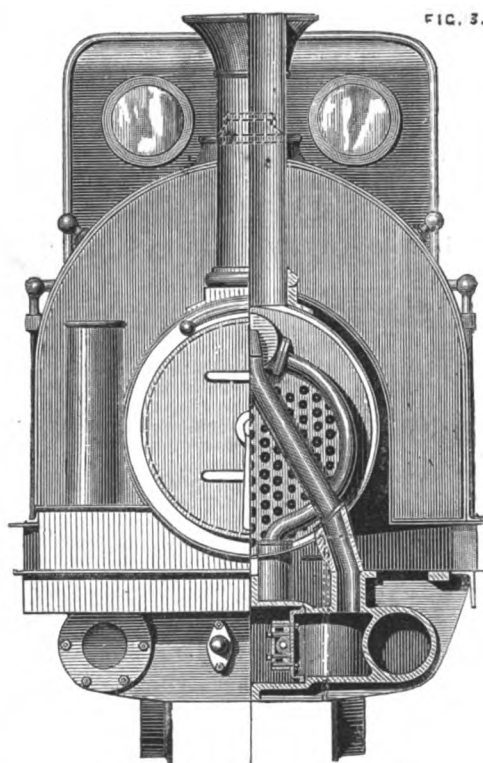


FIG. 3.

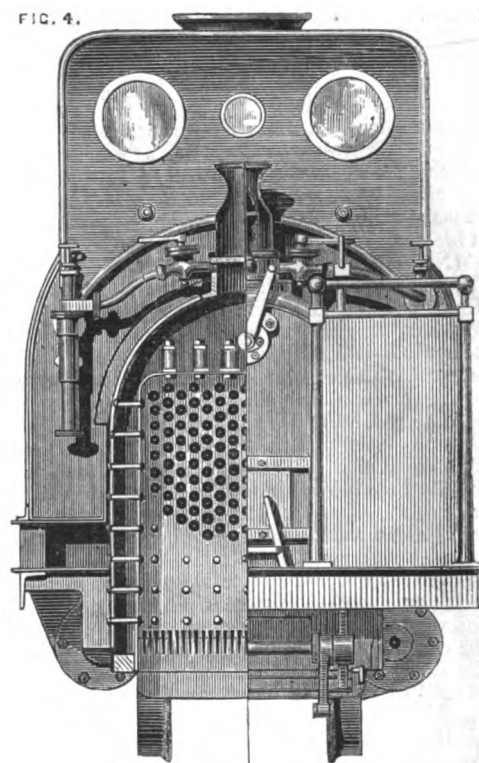


FIG. 4.

effected by the substitution of steam for horse traction being stated by Mr. Spooner to amount to about 22 per cent. In conclusion, we should state that the engravings of the locomotive which accompany the present notice have been prepared from tracings with which we have been kindly supplied by Messrs. G. England and Co., and for much of the information concerning the line itself we are indebted to Captain Tyler's paper, to which we have already referred.

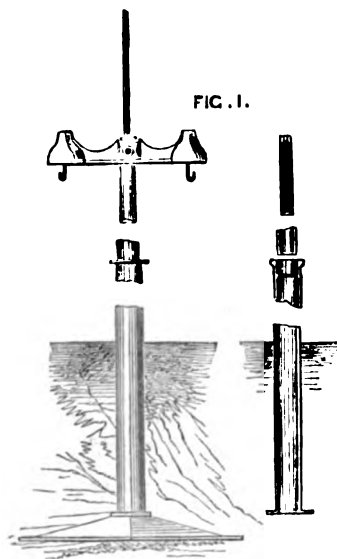
FOREIGN STEAM SHIPPING.—The new French steam line between Marseilles and La Plata has made a beginning. The first vessel of the line, the *Bourgogne*, arrived recently at Buenos Ayres. It is proposed to commence running next month a line of Spanish steamers, which are intended to place the ports of Barcelona, Marseilles, and Genoa in regular relation with the Levant, and especially with the island of Cyprus. Many new steam lines have been started lately.

ELECTRICITY AT THE PARIS EXHIBITION.

Siemens.—In the annals of the applied sciences there is no name either on the Continent or in England that is associated with so many various and opposite inventions as that of Siemens. In metallurgy, mechanics, heat, light, and electricity, it stands in the foremost rank. On the present occasion, we have nothing to do with his new steel process, his regenerative furnace, his parabolic governor, *et hoc genus omne*, but simply to review his electrical exhibits at the Paris Exhibition. The firm of Messrs. Siemens is almost cosmopolitan. The parent establishment for telegraphic apparatus—that of Messrs. Siemens and Halske—is at Berlin; their branches have settled on the Thames and the Neva; their products are to be seen upon the banks of the Indus, the Nile, the Orange River, the Amazon, the Euphrates, and nearly every other stream mentioned in history or geography. The firm established in England is that of Siemens Brothers, and their manufactory for electrical apparatus is at Charlton, near Woolwich; the head of this firm is C. W. Siemens, F.R.S. Their stall in Paris contains unquestionably the finest display of telegraphic apparatus in the whole building, and they most deservedly were awarded a gold medal.

In our previous notice of iron poles we omitted to mention Messrs. Siemens's latest form of their tubular iron telegraph-post. Iron is not used in Europe because wood is sufficiently abundant and more economical, but in hot countries decay is so rapid even with the hardest and best wood that iron has become almost imperative. Many forms have been used, and Mr. Siemens himself has tried several before he produced the light and elegant post which we illustrate. Each post consists of

1. A dished or buckled foot-plate of wrought iron, which is attached by means of four bolts to
2. A cast-iron tube forming the lower portion of the post, and terminating in a socket to receive
3. A conical wrought-iron welded tube fastened in the socket by means of a liquid sulphur-iron cement.



The post, as illustrated, stands 16 ft. above ground, and weighs about 1½ cwt., or half the weight of an ordinary wooden pole of the same height. They have a very smart and light appearance when erected, and they are fixed with marvellous celerity. They are peculiarly adapted for transport, and many of them are now being sent out to Abyssinia to maintain permanent telegraphic communication with the expedition that is being sent into the interior. It is rather an interesting fact, and one illustrative of the difficulties of maintaining telegraphic communication in perfect order in half-civilised countries, that Messrs. Siemens have recently been perforating the buckled plates that form the feet of the poles, because it was found that the natives dug them up to use them as kettles to boil their rice and perform other domestic culinary operations.

Their insulators were described and illustrated in our review of that branch of telegraphy. It is their instrument department that now comes immediately under review. There are three striking points evidenced in their instruments that singularise this firm at once from all other makers:

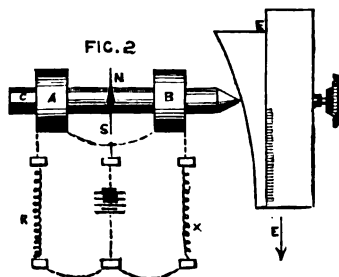
1st. The admirable compactness of all the recording instruments and their accessories—relays, keys, commutators, &c.—everything being arranged on a solid

bold mahogany board with connecting wires protected and hidden, but easily manipulated.

2nd. The massiveness and solidity of the working parts, and yet the perfect finish and admirable relative proportions of every—the most delicate—adjustment.

3rd. The artistic appearance of the arrangements, and the fine colour of the lacquering.

We have here complete sets of their submarine recording instruments, which were used upon the Red Sea cable, and are now used upon the Malta and Alexandria and Persian Gulf cables; their direct-working, ink-recording instrument, both polarised and non-polarised; their magneto-induction keys, which dispense entirely with the use of batteries; and their world-famed polarised relay, which is unquestionably the most valuable and serviceable instrument of its kind ever invented. There are, also, alphabetical dial instruments for private and military use, constructed on their well-known models—portable and non-portable—and a remarkably simple portable sounder for military purposes, to enable the operator to read by ear instead of by eye. There are, also, lightning-dischargers, telegraph-cables, batteries, alarms, clocks, &c. All these are well known, and offer no particular points of novelty for illustration; but amongst the apparatus exhibited for testing, and more exact purposes—Bridge's, Wippe's, and Galvanometers—there is one that merits particular attention for its novelty and great utility, viz. the *Resistance-measurer*, which is based upon a simple differential method, and supercedes the use of resistance coils.



Two small bobbins, A and B, one containing in its circuit the unknown resistance, X, the other a constant resistance, R, are connected parallelly, so as to have an opposite action upon a magnetic needle, N S, which is suspended by a cocoon fibre between them. These two coils partially neutralise one another in their action upon the needle, and it is evident that, by altering the distances of one or both, they may be made to balance each other entirely.

This is done by moving horizontally the two bobbins which are fixed both on the same slide, C D, i.e., so as to alter their relative distances from the magnetic needle.

For instance, if the unknown resistance, X, increases, then to re-establish balance, the slide on which the bobbins are fixed has to be moved in such a direction as to make the distance between the needle and the coil, B, which contains the increasing resistance, smaller, and consequently the distance of the other bobbin and needle larger.

Thus the unknown resistance, X, may be expressed by

$$X = f\left(\frac{d}{D}\right) \times \text{Const.},$$

where d and D are the respective distances of the two coils from the needle, and f a function, complicated in its mathematical form as long as the distances d and D are not very great in comparison with the dimensions of the coils and needles, but is, however, easily to be found empirically by experiment. Equal differences of resistances do not correspond to equal movements of the two bobbins, and it would, by directly moving the slide of the respective bobbins, require either a table which gives for every distance the corresponding resistance, or a formula by which the unknown resistance may be calculated if the distance at which balance is established is found by experiment. But both these ways are not convenient in practice, and for this reason the slide is not moved directly, but pressed by a spring against a curve, E F, such that when the curve is moved equal distances in a direction at right angles to the slide, by means of a rack and pinion, the slide on the two bobbins are moving unequal distances, so as to fulfil the equation,

$$X = f\left(\frac{d}{D}\right) \times \text{Const.}$$

at each distance.

This arrangement makes it possible to read off the resistances directly, on an engraved scale, without hav-

ing any calculation whatever. The limits between which such an instrument measures resistances depends on the resistances of the two bobbins, and their minimum and maximum distances from the needle. The one at the Paris Exhibition measures distances between 0 and 15,000 Siemens Brothers' units.

This instrument promises to be a very valuable addition to the apparatus of the non-mathematical and not-deeply-read electrician. Any man of the most ordinary intelligence can adjust a needle to zero, and read off the graduations of a scale. The sine galvanometer requires calculation, and the differential galvanometer and bridge require various resistance-coils which are often very variable and very expensive. This new resistance-measurer avoids both, and, moreover, should be cheap, from the comparative simplicity of its construction, and it is said to be capable of employment by an unskilled operator with as much exactness as Wheatstone's bridge itself. It can also be adjusted to either *Ohms* or *mercury units*, so as to avoid the present troublesome calculations required through the use of different units by different engineers. It fully maintains the great inventive skill of the house of Siemens, who have certainly led the way to the present exact method of measurement in all branches of electrical knowledge, both practical and theoretical. Messrs. Siemens and Halske have also a magnificently fitted-up stall in the Prussian department, where they exhibit a large array of apparatus, principally upon the same models as those in the English department—as regards instruments. They exhibit Siemens's new electro-magnetic machine, which, however, has been rather thrown into the shade of late by more recent improvements, although the secret of the success of all these wonderful machines—Wyll's, Wheatstone's, and Ladd's—lies in the peculiar longitudinally wound armature which is Siemens's. The Berlin firm also exhibit a capital type-setter, or machine for setting up messages in metal types bearing the Morse characters; but it does not seem to have come into general favour. Altogether, Messrs. Siemens's exhibits put those of every other country completely in the shade, and they deservedly maintain the position they have made—that of being the first electrical manufacturers and engineers in the world.

CLIMBING BY RAILWAY.

It appears extraordinary that engineers seeking to climb steeper and steeper gradients—already working up 1 in 12 by locomotives, and asking themselves whether an all-coupled engine, by itself, would really manage to just get up 1 in 4 by its own adhesion—never appear to have thought that as much power is generated by gravity in going down these slopes as is expended in overcoming gravity in going up. Any means that will utilise the gravity of a train on a descending incline will solve the problem of working a train up the same incline, and so far from being limited to a rise of 1 in 12 we may have a rise of 1 in 0, or, in other words, work up and down vertically, which would more than meet the case of Chimborazo or the Matterhorn itself—and, seriously, there is no knowing where engineers will be climbing to next. An ordinary locomotive will take care of itself very well on any gradient less steep than 1 in 20, performing more or less work according as the gradient is flatter or not. But for much steeper inclines there is no reason why we should always design them just as if all the trains were to go up and none were ever coming down again. Yet this is what the Mont Cenis Railway engineers have done. Every time Mr. Fell's 16 ton engine and a train of 24 tons goes over the mountain, in either direction, 80,000 foot-tons of available power are absolutely thrown away, taking the total descent as 2000 feet. Nearly as much power is thus lost as is required to get the train up to the summit.

On the inclined planes sometimes employed about collieries and ironstone mines, the loaded wagons, in going down, are made to draw the empty wagons coming up. This plan, however, involves the use of ropes, and it is obvious that it is only applicable where the preponderating traffic is all downward, and where trains are always ready, at the same moment, to move in both directions. It applies only to planes inclined in one direction, or, if in both, where the loads are made up at the summit; and it is clear that, except it were supplemented with a system of separate engine power, this system would be wholly inapplicable for working a varying passenger traffic over the Mont Cenis, and in any case it would almost certainly involve considerable detentions, inasmuch as passengers could only go up at the precise moment when other passengers were going down. It would, of course, in-

volve a double line of way, whereas the present zig-zag line over the mountain is single.

What is wanted is a single-line system, whereby one train, going down at one hour, or one day, may store up its gravitating power to be used the next hour, or even the next day, to help another train up. As a mechanical problem, and this is one of very great interest and importance, there are, perhaps, two or three ways of working this out. We may conceive a rope system, in which the descending trains are made to pump water into an accumulator, the water pressure thus stored up in which is to be made available for taking up a train in the opposite direction, on the same line, at any time afterwards. This plan would involve, however, very considerable losses from friction, and the rope system is always objectionable. In case of a sufficient supply of water at the summit of the incline, the descending trains might be made to carry down a certain weight of water in tanks, say 10 or even 20 tons (2240 to 4480 gallons), to assist in pumping up a sufficient force for taking up other trains, not thus loaded, in the opposite direction.

There is another system, preferable, we think, to this. This is that of a pneumatic tube, not upon Mr. Rammell's plan, but one, nevertheless, in which the train goes through the tube. Rails could be laid, and an ordinary railway train (without the engine) could be run into a 10 ft. or 11 ft. tube, and a pressure of but 1 lb. per square inch—not much greater than that corresponding to the difference between a very low and a very high barometer—would give a tractive force of 5 tons in the 10 ft., and 6 tons in the 11 ft. tube. This would take 20 tons easily up a slope of 1 in 4 to 1 in 5, and it is to be borne in mind that no locomotive is to be taken up. The air, under pressure, would not be blown directly from the engine into the tube, for in that case no advantage could be taken of it in descending. It would be accumulated in an air-holder, or accumulator, like a gas-holder, and having a capacity somewhat greater than that of the tube itself. For every mile of a 10 ft. tube, the air-accumulator would require to have about 400,000 cubic feet capacity, corresponding to a gas-holder of very moderate size, the largest gas-holders having a capacity of 2,500,000 cubic feet. The air-accumulator would require, however, to be of considerable strength, and to be loaded with considerable dead weight, to be worked at a pressure of even 1 lb. per square inch. If 120 ft. in diameter, it should weigh, loaded, about 725 tons, merely in order to keep it down, in its tank, against this pressure, and the difference of level of the water, on the two sides of the "seal," would be 2 ft. 4 in. This air-holder would be placed at the foot of the incline, and filled, at the outset, by a blowing engine of moderate size, and this would be afterwards employed in supplying the waste of air in working. The air-holder would empty itself, or nearly so, in sending a train up, and would be nearly filled again by the air forced in by a train of the same or of rather greater weight coming down, the difference of quantity of compressed air being supplied from the blowing engine. The principle and its great advantage will be seen and understood without difficulty. It requires a certain amount of detail in working out, but this presents no difficulty, and may be designed with certainty, and even with ease. The train would be run into the tube, leaving the locomotive behind, and the doors of the tube would be shut. A piston truck, nearly but not quite fitting the tube, would be placed in advance of the train, or perhaps two, one in front and one behind. The compressed air would then be let on through a valve whose opening would just suffice to send the train up at the proper speed. The upper end of the tube would be always open, unless a narrow summit had to be passed, and a descent made on the opposite side. In the latter case, a short piece of level line would be introduced at the summit, and, on reaching it, the pressure in the up tube would be let off into the down tube, thus placing the train in equilibrium, and storing up a certain amount of air in the down tube to check the train in the beginning of its descent. In the case of a plane rising merely from a low level to a table-land above, like those up the sierras in Brazil, or up the ghauts in India, the upper end of the tube would be always open. The carriages would require to be lighted in passing up or down the tube, but the ventilation would be perfect, the motion delightfully uniform, and nothing could possibly be safer. We have, ourselves, been through Mr. Rammell's little tubes, one of them equal in area only to a 33 in. and the other to a 54 in. main, and the motion, despite the small wheels of the trucks and the absence of springs, is like sailing, and the ventilation is very good.

Upon the plan we propose trains might be worked up any incline, however steep, or even be lifted vertically, in perfect safety, and with the utmost steadiness and comfort.

SCOTCH BLAST FURNACES.

THERE are at the present time three distinct schools of iron-smelters in existence in this country. Their systems and practice have grown up and established themselves according to the natural conditions provided in each special locality for the supply of raw materials, and according to the nature and quality of these latter. The distinctive features in the natural conditions of each of these three schools may be expressed in the following combinations: viz., rich ores and dear fuel, poor ores and cheap fuel, and rich ores and cheap fuel; the fourth and only remaining variation, viz., poor ore and dear fuel, has, from an obvious reason, never found favour with commercial ironmasters. The combination of rich ore and dear fuel we find in the hematite district of Ulverstone and Barrow-in-Furness, and we have made our readers acquainted with the system of working adopted in some of the ironworks in that locality. The second combination, viz., poor ore and cheap fuel, is the characteristic of the Cleveland district, and it is there where the science and skill of engineers and managers of blast furnaces have done most to compensate for comparatively unfavourable primary conditions, and where the practice of iron-smelting may be said to stand at the height of its present scientific development. Of the ironworks of the Cleveland district, too, we have given numerous and complete descriptions in our columns. We now come to the third school of ironmasters, the oldest and most favourably situated with regard to natural facilities, viz., cheap coal and rich ore. The proper representatives of this group are the ironmasters of Scotland, with their blast furnaces placed at the mouths of the pits, which provide both ore and fuel at the same time; the former being the richest iron ore known in practice, and the latter being furnished at a very small cost.

The Scotch blast furnaces work with raw coal and with calcined blackband ore; they range between 40 and 60 ft. in height, and have a weekly production of between 150 and 200 tons per furnace. The calcined ore contains from 60 to 70 per cent. of iron, and is reduced at a comparatively low temperature; the iron, too, containing about 0.5 per cent. of phosphorus, melts at a very low heat, and maintains a high degree of fluidity down to the point of its solidification. All these conditions are favourable to smelting at a low temperature, and induce the employment of raw coal instead of coke. In the manner in which coal is used in the Scotch blast furnaces, its effect is due only to the coke contained in it, the volatile components of the coal being entirely useless, as they are allowed to escape at the top of the furnace. The process of coking or distillation of the coal which goes on in the highest part of the furnace, moreover, consumes a certain amount of heat, and reduces the temperature of the furnace itself. The appearance of the flame at the top of the furnace gives no correct indication of the real temperature existing in the upper zone of materials, since the gases are ignited when they come in contact with the outer atmosphere, and after their having left the furnace itself. The quantity of coal charged into the furnace, independent of any further quantity used for heating the blast and firing the boilers, is rarely less than 50 cwt. per ton of iron made, and it occasionally exceeds that proportion. Estimating the coke contained in this coal at 60 per cent., we find the consumption of fuel in the furnace equivalent to 30 cwt. of coke per ton of iron. In the Cleveland district, 18 cwt. and even 17 cwt. of coke will produce a ton of iron, this consumption including all the fuel required for the hot blast and boilers, which are fired by the waste gases. It appears, therefore, that independent of the waste of the gaseous components of the coal, the Scotch furnaces consume a quantity of fuel per ton of iron made fully twice as great as that required in the furnaces of the Cleveland district. In such a comparison, a further allowance should be made for the difference in quantities of raw materials passed through the furnace in making a ton of iron. In Cleveland, upwards of 4 tons of raw materials are charged into the furnace along with the fuel, while in Scotland the average is only two tons of ore and limestone; and occasionally—as, for instance, at the Gartsherrie works—less than that quantity is employed per ton of pig iron. With regard to economy of fuel, it is obvious, therefore, that there is room for great and important improvements in the blast furnace practice of Scotland. The second

point for consideration in the working of a blast furnace is quantity of production. In this respect, we find the Scotch furnaces averaging about 200 tons per week, and a very considerable number of them come far below this average.

For judging correctly on this point, we must compare the Scotch furnaces with those of the hematite district, where the ore employed, although not quite so rich as the blackband, comes sufficiently near the latter in its percentage of iron. Here again we find that at Barrow the production of each furnace amounts nearly to 500 tons per week, or more than double that of the largest Scotch furnaces, and room for improvement on this head seems to be clearly visible in the practice of the latter. Attempts have been made to increase the production by building higher furnaces. There are, for instance, two furnaces of 60 ft. in height at work at Gartsherrie; but the results obtained with these are not favourable. Their make is not materially greater, and the proportion of fuel no better than that of the lower furnaces, while, on the other hand, they are troublesome in "working." The term "working" applies to a peculiarity of Scotch blast-furnace practice not known, to any similar extent, in other districts. It appears that the materials, arriving in front of the tuyeres, do not sufficiently support themselves in the boshes to keep the hearth clear from solid matter, and that the latter, falling down in detached pieces or lumps, must be cleared out of the hearth, and raised up above the tuyeres by hand-labour. This operation requires constant attention and care, several men being employed at each furnace for "working" it by means of large wrought-iron bars inserted through the cinder-hole, or in other suitable positions below the tuyeres. This fact clearly shows that the burden of the blast-furnaces now in use is already greater than they are capable of carrying, and this is corroborated by the fact that this "working" may be lessened, or almost dispensed with, by reducing the quantity of make. It is obvious, therefore, that an increase in height of a furnace under such circumstances will not afford any advantage; it appears equally obvious, however, that the shape of the existing Scotch furnaces at the boshes, and, perhaps, throughout the whole body, must be at fault, and not well suited to the nature of the materials smelted in them. It would be difficult to say, *a priori*, in what particular manner the shape of these furnaces could be improved; but it seems likely that the shape of boshes adopted by Mr. Addenbrooke, in his new blast furnaces in Staffordshire, would be very suitable for Scotland.

Mr. Addenbrooke brings down the lines of his furnace almost parallel to a very low point, and then draws them in quickly towards the hearth, so as to form a kind of resting-point or abutment above the tuyeres, upon which a kind of dome is formed by the solid material, this carrying the burden of the superincumbent mass. Mr. Addenbrooke's furnaces are said to work very well, and the same form has been adopted by Mr. D. Adamson in his new blast-furnaces in North Lincolnshire, with a very complete success as to the mode of working and of supporting the burden. With an improved capability of carrying the burden, there can be no doubt that the rate of production of the furnaces in Scotch ironworks could be increased by increasing the height of furnace and the pressure of blast, but there is very little reason for supposing that such an improvement would at the same time cause a great and important economy of fuel. The process of distillation of coal, and each of the different successive stages of smelting, would take place the same as at present, only occupying larger spaces or zones in the furnace, which would be passed through at a greater speed, and would, therefore, occupy the same total length of time as they do at present. There would be the same waste of gaseous products, the same reduction of temperature in the upper strata, and only some minor advantage might arise from the greater heat maintained in the lower portion of the furnace in consequence of the greater intensity and speed of combustion under a greater pressure of blast. The proper and main road for improvement in the blast-furnace practice of Scotland, and one which, in all probability, will have to be taken before long, is the utilisation of the waste gases. It is a moderate estimate to say that a Scotch furnace sends twice as much unconsumed fuel up into the air as is consumed within it for useful purposes. We do not venture now to predict in what precise form or manner this utilisation of the volatile components of the coal may take place at some future period; but any mode of effecting this important object will be beneficial and conducive to a great saving of fuel. The simple expedient of closing the

top of the furnace, and drawing off the gases for firing boilers and stoves, is of course, that which will immediately recommend itself. It has the advantage of being sufficiently tried and proved successful by the practice of the majority of ironworks all over the world. There can be no doubt that the growing competition of the Cleveland district will before long bring the Scotch ironmasters down from their present aristocratic habits to a rational economy of fuel, an economy by which the ironmasters themselves will be the greatest gainers.

THE COATBRIDGE TIN-PLATE WORKS.

THE manufacture of tin plates is a speciality confined to a very limited number of districts, owing to the great amount of experience and skill which it requires for being worked to commercial advantage, and also owing to the fact that it requires raw materials of a special quality not easily obtained everywhere. The raw material for the tin-plate manufacturer is iron scrap or charcoal pig iron. The former material, which in this country is mostly scrap from coke iron, is worked up with coke, and furnishes the inferior kinds of tin plates, which are sold as second and third qualities, at a price averaging about 4s. per cwt. below that of the first-class or charcoal tin plates. These latter are made from charcoal iron, and with the use of charcoal in their complete manufacture. They are superior in pliability and ductility to the coke plates, and they therefore stand a much larger amount of wear. The tin-plate works at Coatbridge, near Glasgow, were established only a few years ago. They are now in the hands of a limited-liability company, viz., The Coatbridge Tin Plate Company (Limited), and are in very successful operation, both with regard to quality of production and commercial results. The possibility of making good tin plates from Scotch scrap iron was very much doubted at an earlier period; but the working of this establishment has sufficiently proved the very good quality of Scotch scrap. The scrap iron is welded and hammered up into blooms, which are afterwards rolled out to a small thickness. After that, the plates so produced are doubled up and passed through the rolls, and this process is repeated until the sheets pass the rolls of eight plates or more. The plates forming one pile are separated by hand, as they are caused to adhere to each other by the layers of scale or oxide pressed in between their surfaces. After this, the coating of scale is removed from the metallic surfaces by a pickle or bath of sulphuric acid, and an annealing process follows this removal of the outer scale. The plates are enclosed in square cast-iron boxes for the purpose of preventing the access of the atmosphere and further oxidation during the annealing process; still this precaution does not prevent a slight coating of oxide from appearing on the surface of each plate, this coating giving it a dull appearance. Each plate is then singly passed between a pair of chilled rolls with very fine bright surfaces, and these rolls produce a smooth surface, which is once more cleaned by dipping into diluted sulphuric acid. The operation of tinning, which follows immediately afterwards, consists in simply dipping the plate vertically into a vessel containing molten tin. The plate itself is not heated, and the operation of dipping is very short. It is immediately followed by an immersion of the plate in melted tallow for allowing the surplus tin to drop off, and some ingenious arrangements and much manual dexterity are employed for removing the last particles of surplus tin from the edges and sides of each plate. The tallow is ultimately removed by passing each plate through a heap of waste from flour mills, which, when saturated with greasy matter, is employed for feeding cattle. The trade in tin plates we understand to be brisk at present; at least, there have been some considerable sales made by the Coatbridge works to the furnishers of provisions for the Abyssinian expedition.

NEW DOCKS AT BELFAST.—Yesterday the Lord Lieutenant of Ireland opened, with a formal ceremonial, a new dock at Belfast. This dock consists of a large basin 700 ft. long by 700 ft. wide, called the Abercorn Basin, in which is a new graving dock, to be entitled the Hamilton Dock, 450 ft. long by 80 ft. wide at the coping and 50 ft. at the bottom. The whole surface is covered with a layer of concrete 2 ft. thick, which is overlaid with Dungannon sandstone 4 ft. deep. It is built in the most substantial manner, and is provided with the most improved arrangements. Outside the basin is a sill, which is finely grooved with granite from Castlwellan, county Down, the material which is used in the Albert memorial in Hyde Park. The work being constructed chiefly of materials procured in the neighbourhood of Belfast, and by local workmen, has been a source of profitable employment.

TRIALS OF REAPING-MACHINES IN SCOTLAND.

FOR the last few weeks, competitions and friendly trials of reaping-machines have been the order of the day in Scotland. On Tuesday of last week, there was a competition at Auchterellon, in connexion with the recent show of the Royal Northern Agricultural Society. Much interest was manifested in the display, as farmers are year by year getting more anxious about the rapid reaping of their crops during good weather. Premiums were offered by the Society, and eleven reaping-machines entered for them, in addition to four extra machines which were simply entered for exhibition. The machines were set to work in a twenty-acre field of oats after turnips, and afterwards tested in a field of oats after lea, where the crop was strong and much laid and twisted. Altogether the machines did their work well, and the results of the trial were very satisfactory. The judges, including two Aberdeen engineers, gave the following awards, after very careful and anxious consideration:

Two-horse Manual Delivery Reaping-Machines.			
Exhibitors.	Makers.	Awards.	
Cardno & Darling, Aberdeen	Brigham & Bickerton, Berwick-on-Tweed	1st Prize.	
Harper & Co., Aberdeen	Kemp, Murray, and Nicolson, Stirling	2nd do.	
A. Spence, Aberdeen	Walter Wood, London	3rd do.	
One-horse Manual Delivery Reaping-Machines.			
B. Reid & Co., Aberdeen	Samuelson & Co.	1st Prize.	
Harper & Co.	Kemp, Murray, and Nicolson	2nd do.	
A. Spence	Walter Wood	3rd do.	
Two-horse Self-Delivery Reaping-Machines.			
Cardno & Darling	Brigham & Bickerton	1st Prize.	
B. Reid & Co.	Samuelson & Co.	2nd do.	
Harper & Co.	Kemp, Murray, and Nicolson	3rd do.	

Extra Machines, not in Competition.
A two-horse self-delivery reaping-machine, exhibited by Mr. Murray, Banff—Hornaby and Son, Grantham, makers—highly commended.
A two-horse manual-delivery reaping-machine—exhibited by Messrs. Simpson and Co., Peterhead—Mr. Jack, Maybole, Ayrshire, maker—commended.
A two-horse mowing and reaping machine, manual delivery—Brigham and Bickerton, makers—commended.
After the trial of the reaping-machines, a double-furrow plough invented and patented by Mr. Pirie, of Kennamund, Longside, which was simply entered for exhibition, was set to work on account of the great interest with regard to it. The main purpose of its inventor is to accomplish double the work of the ordinary plough with little extra draught on the horses. It was tried both on lea and stubble, and elicited high commendation. The dynamometer showed the draught to be 5½ cwt. on Mr. Pirie's plough, as against 3½ cwt. on an ordinary plough. On the farm of Overfield, near Whittingham, Haddingtonshire, two reaping-machines of very dissimilar construction were, on Thursday last, put in friendly rivalry, and were both thoroughly tested in presence of a number of the agriculturists of East Lothian, a country famous in the annals of agriculture for its high farming. One of the machines was from Mr. McCormick, of American celebrity, and the other from Messrs. G. and W. Porteous, Haddington. The American, or larger implement, was exhibited by Mr. Griffin, the agent. Since its introduction into East Lothian, this machine has undergone great improvement. It is on the side-sheaf delivery principle, the raking being performed by means of an eccentric, which tilts the grain over the side of the platform clear of the path of the horses. When first brought out it had a huge lumbering appearance, and left the sheaf of a straggling character, but these drawbacks have now been almost wholly removed. The machine is reduced in size, is compact and tidy-looking, and its draught has been greatly lightened. The mechanism for delivering the grain has also been so much improved, that the sheaf is thrown off with a neatness and compactness that all but rivals that of the best hand-raking. Still, the large size of the machine, its great liability to derangement from the complexity of its parts, and its greater cost, are important drawbacks, which would militate against its extensive introduction, were they not counterbalanced by the great saving of labour which it is capable of effecting, and its ability to cut without requiring the immediate presence of a band of lifters out of the horses' way. The cutting performed by the McCormick machine on Thursday last was extremely well done; indeed, where the lie of the grain favoured the action of the knives, nothing could have been better, and the sheaving was fully superior to any that is usually seen at competitions of side-deliverers.

The machine of the Messrs. Porteous is a much lighter implement than the McCormick, weighing probably not more than 6 cwt., with a very moderate draught on the horses. As a two-horse back-deliverer, cutting to a full average breadth, it is decidedly one of the lightest and neatest reaping machines yet brought into the harvest-field. The great object of the makers has been to combine the greatest possible lightness of draught with the most effective cutting, and the utmost possible strength to resist tear and wear. Simplicity of motive power and a minimum amount of friction have been aimed at, and so far as Thursday's results may be taken as a criterion, the machine quite realised everything that the makers could reasonably have anticipated. The cutting was unexceptionable, close, regular, and easy, and the rapid movement of the knives enabled the horses to move with a steady pace without requiring extra speed to be put on them. This machine will not readily be surpassed as a thoroughly handy reaper, able for its work, light of draught, and yet strong enough to resist all the rough tear and wear of the harvest-field. The trial was made in a field partly barley and partly wheat. The crops were not heavy, but stood well up, and furnished a very fair test for machine-reaping.

Mr. Howard, of Bedford, when recently in America,

thought very light of the performance of a self-delivery sheaf-reaper he had seen there. One of these he exhibited at the Agricultural Exhibition at Billancourt where it was tried, but the performance did not come up to expectation. During the harvest in England this year there were good opportunities for testing the working of the machine.

Several alterations having been made on it, and the various parts being adjusted to the kind of crops in Scotland, the eminent Bedford firm thought they were justified in sending the machine north, as a considerable improvement on any hitherto in use. It was tried on Wednesday last on the farm of Mr. P. McLagan, M.P., Pumphrestone, Linlithgowshire. After going two rounds, the iron bearing which supports the revolving rake gave way. The machine was repaired, and work recommenced on Thursday on a crop of oats, after pasture, fully ripe, and considerably laid, though only slightly twisted. So far as the trial went, it could not be said that the work done was in any manner better than has often been effected by several of the many self-delivery sheaving-machines, neither did the method of working or the general appearance of the machine give much promise of its ultimately becoming superior in the harvest-field to Samuelson's reaper, which in certain respects it resembles. Motion is communicated from two small-diameter wheels to a knife-bar with fingers very much the same as the newer reapers. There is a circular platform on which a raking apparatus works, consisting of four arms, on two of which there is a rake, and on each of the others a gatherer, too short even to reach the lying corn. The motion is successfully conveyed to the rake by means of chains, and the universal-motion joint in which they start works very pleasantly. The whole machine weighs about 10 cwt., and is apparently well put together. So far, however, as the marsh rake goes as an improvement, there is little to recommend it; and in regard to the cutting apparatus, there is nothing new in it by which laid crops can be more readily taken up.

So far, then, a complete reaping-machine is yet to be made. Taking both cutting and laying into consideration, no reaping-machine recently brought into notice seems much superior to the original one invented by the Rev. Patrick Bell, now some forty years ago; and it would therefore seem that his invention had much more completeness in it than many people out of Scotland are willing to admit.

THE MERRYFLAT BRICKWORKS, GLASGOW.

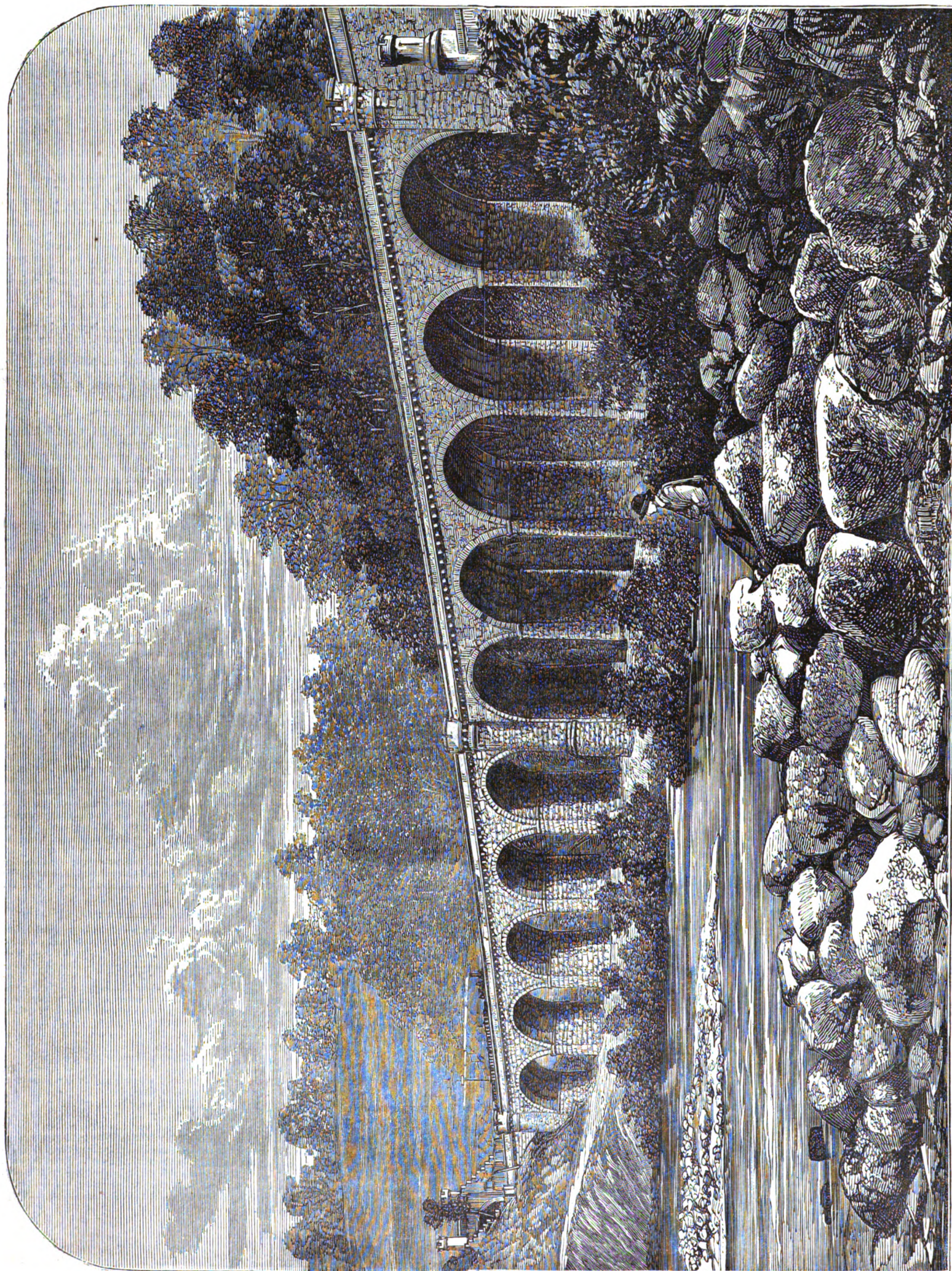
(FROM OUR OWN CORRESPONDENT.)

THESE works, established by a private company about three years ago, although as yet of moderate extent and productive power, deserve some notice on account of their being the first attempt made in Scotland to carry on brick-making by modern and improved machinery and plant. The machinery employed for making bricks from dry clay is that of Messrs. Platt Brothers and Co., of Oldham, of which we have given a description and drawings on pages 195, 197, and 198 of our third volume. The plant is intended to consist of a pair of these machines, each capable, when fully employed, of producing 20,000 bricks per day, but at present there is only one machine erected. Another machine for making bricks from wet clay is also employed at these works, the clay being supplied from an adjoining field, and being very often so wet, through atmospheric influence, that the drying process is discarded with, and the wet-clay machine is supplied with this material. For burning the bricks, one of Hoffman's patent kilns has been just completed and set to work. It is a circular kiln, 100 ft. in diameter at its base, and divided into twelve compartments, each capable of holding 10,000 bricks. These compartments are charged in rotation, one compartment per day, and the circle is completed once every fortnight, giving a daily production of 10,000 bricks. The fuel used is coal-slack ground to dust by one of the clay-preparing machines, an operation which is performed very quickly and at small cost, and which affords the advantage of a very uniform and suitable quality of fuel. The kiln was built from bricks made at these works and burnt in open kilns, as is still the case with a portion of the present production, which exceeds the capability of the new kiln. The lining between the outer and inner walls of the kiln has been made of calcined iron ore of inferior quality, which, with a very low price, combined the advantage of being a very bad conductor of heat, and entirely free from moisture after its calcination. The top of the kiln is to be covered by a roof, and will form a very convenient drying-shed for the bricks. The managing partner of this concern, to whom the introduction of this modern plant seems to be due, is Mr. W. R. Watson, of Glasgow.

THE METRIC SYSTEM.—We believe it to be now well nigh hopeless ever to expect the introduction of the decimal or metric system into English workshops. A new objection has been found, which, we believe, has been discovered solely by the sagacious editor of *The Engineer*. "It would," he says, in a footnote to a really able and excellent letter with which he has been favoured by an intelligent correspondent, "enormously depreciate the value of existing drawings and patterns!" Good gracious! who else could have foreseen this? Would it not also depreciate the value of existing land, or existing railways, of existing Consols, and of certain existing journalists? We had always supposed that a full-size drawing or a pattern was of a constant size, whether measured by a 2 ft. rule or by a metre, the difference being one not of magnitude, but of numeration. As for drawings to a reduced scale, and which are commonly figured, it would not be difficult to affix figures, in red, giving the dimensions in metres and millimètres. Drawings supplied to us for our own draughtsmen and engravers are occasionally marked in this way, and in feet and inches as well. Indeed, the decimal system has been already introduced into English workshops, among them Mr. Whitworth's, Messrs. Sharp, Stewart, and Co.'s, and those of the Midland Railway Company at Derby. It will, we have no doubt, be further introduced, and that without any enormous depreciation of the value of existing drawings or patterns.

THE KILLICRANKIE VIADUCT; HIGHLAND RAILWAY.

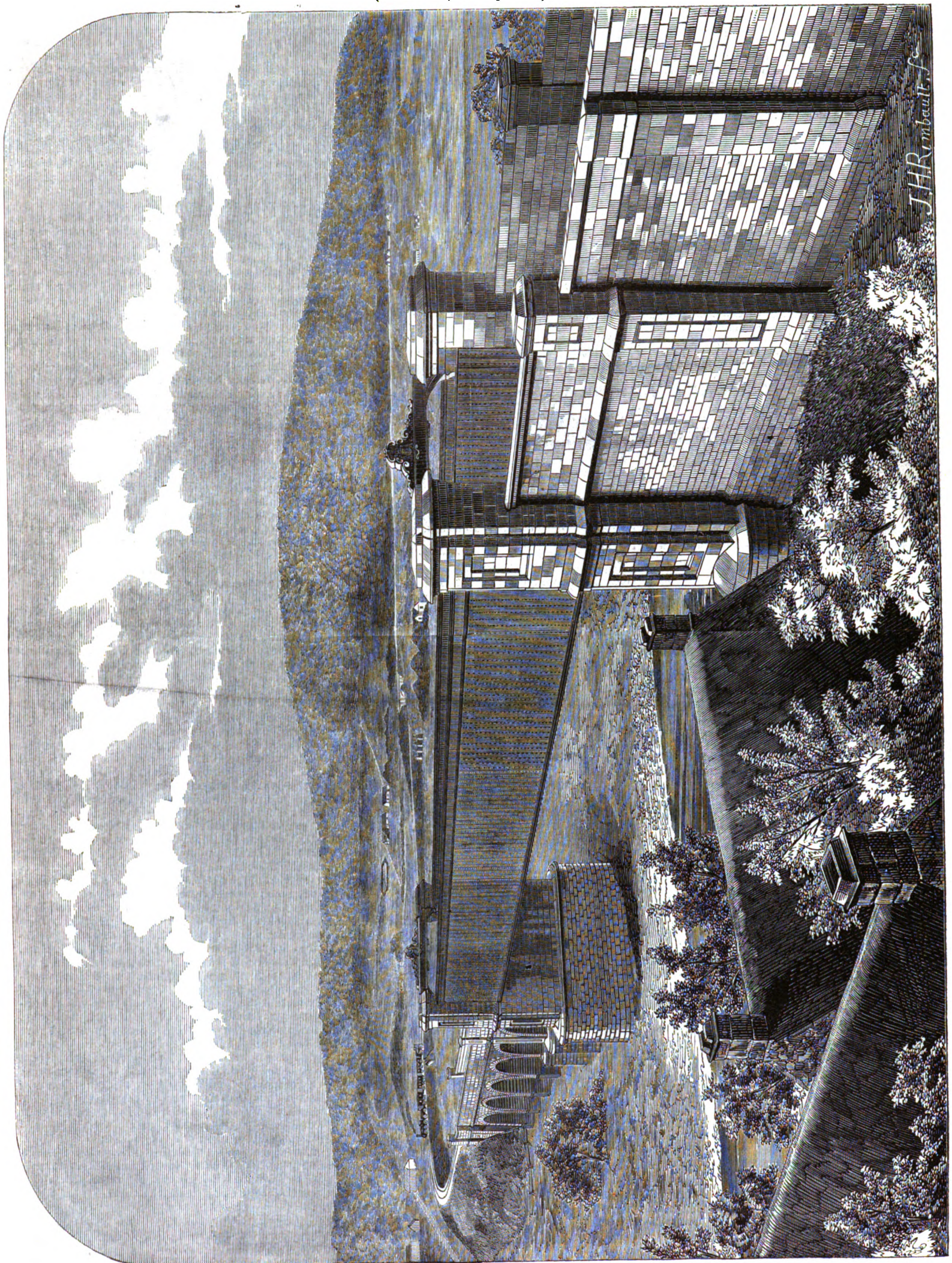
MR. JOSEPH MITCHELL, ENGINEER.

(For Notice, see Page 323.)

THE SPEY VIADUCT; HIGHLAND RAILWAY.

MR. JOSEPH MITCHELL, ENGINEER.

(For Notice, see Page 323.)



MALLET MIRUM IN MODUM.

Those who, more than two years ago, on the occasion of the discussion, at the Institution of Civil Engineers, on Captain Tyler's paper on the Festiniog Railway, heard a certain sage propound the novel "law," that the cost of making a railway, the weight of its rolling stock, and the cost of working it, were, by a physical necessity, as the cube of the width of the gauge, thought him a little inadvertent, or, possibly, a "wee bit." But he reasserted his wonderful law on a subsequent evening, and, we have every reason to believe, afterwards revised the proofs of what he had said, knowing that it would be read and challenged by the entire profession, and implying that copies of his papers and discussions were sent to the engineering press to be used in any way, short of actual republication, that editors might deem best. This gentleman, who, by the way, schemed the monster mortars at Woolwich, about which there was some hitch, and who, according to a remark once made in Parliament by Lord Palmerston, was "a high authority upon earthquakes," and who, in fact, is an oracular authority upon everything, said, respecting the 2 ft. gauge:

"Reverting now to the purely physical considerations, it appeared to him, as a physical necessity, that not only the original cost of two similar lines differing in gauge, but also the cost of working them, would approach the ratio of the cube of the length of axle, or, what was the same, of the breadth of gauge. A little consideration would show that, however startling, this proposition, without having any pretensions to be a mathematical truth, was nevertheless approximately true. As an illustration of this, if the axle of a carriage, as a cylindrical shaft, exposed to cross strains, were taken, it would not admit of dispute, that for equal strength, on different gauges, the diameter must vary as the cube of the length, or of the gauge; therefore the weight of the axles would be in that ratio, and so must be that of the wheels to carry them. Then as to the carriages; as it was equally undeniable that the weights of any similar structures whatever varied as the cubes of their homologous dimensions, so the weight of the carriages would be as the cubes of the gauge, if the carriages were of equal lateral strength; and the axles and wheels must be proportionate to carry this load. In a word, all the rolling stock would be increased in something like the ratio of the cube of the gauge. If this were so, it followed that the permanent way itself must be increased in a proportionate ratio to bear this load; and if it were true that the cost of haulage was a function of the weight drawn, it equally followed that the rolling expenses, or those for working the line of road, would be about in proportion to this increased weight of rolling stock also. He wished to guard against being mistaken as now speaking mathematically, or as using the cube as a precise expression of the relation; his intention was merely to illustrate the proposition which he deemed generally true—that not only the first cost of construction, but also the expense of working railways, increased with the width of the gauge, but in a greatly higher ratio; or, in other words, that in proportion as the gauge was reduced, both the first cost and the working expenses would be diminished."

What, but the desire to hear himself talk, could have prompted *dicta* like this? In the first place, it "will admit of dispute" that for equal strength the diameter of an axle must vary as the cube of its length, or even as its length simply. If the diameter varied as the cube of the length, then would one axle, twice as long as another, require to have eight times its diameter, and consequently 64 times its cross sectional area, and consequently again 128 times its total weight; so that if an axle for the ordinary gauge weighed 4 cwt., it would need to weigh about 25 tons on a gauge of twice that width! We must suppose, however, from the context, that Mr. Mallet meant that the diameter would vary as the length simply. Here, too, he was equally wrong, and it but shows the charity with which such statements may be received at the Institution that no one gave him a lesson which every draughtsman of millwork, or any one having anything to do with designing shafting, ought to know. The transverse strength of shafting, railway axles, &c., is as the cube of their diameter, and inversely as their length. In other words, if, for the same transverse strain, one axle, being twice as long as another, was made also of twice the diameter, it would have, not the same strength, as Mr. Mallet would make out, but four times the strength, and it would be, therefore, needlessly strong. To double the distance between the supports of an axle of a given diameter would diminish its transverse strength by one-half; but this loss would be restored by increasing its diameter slightly more than one-fourth, 1.26^3 being twice 1^3 . This would increase the cross section 1.5876 times, or as 1.26^2 as compared with 1^2 , and the weight of the whole axle would be increased exactly in proportion to the increased length multiplied by 1.5876 .

So we have got Mr. Mallet out of his cubes into a more simple ratio. We have said nothing about torsion, for with the same length and force this varies not inversely as the cube, but inversely as the

fourth power of the diameter, and hence the increase of diameter that would resist the same transverse strain in the longer shaft would much more than suffice to resist the same torsion. But Mr. Mallet, even if he admits what he will find himself compelled to admit if he ever speaks again upon this subject, will still maintain that the weight of everything about the carriage must increase at least directly as the gauge. "For," he says, "the weight of the wheels must be as the weight of the axles, in order that the wheels may carry the axles!" Well done, more *liberico* Mr. Mallet! True, the wheels do carry the axles; but that is not quite all that they have to carry; and if the length of an axle be doubled, and its weight, for the same strength, increased from, say, 4 cwt. to 12.7 cwt. (instead of 25 tons, as Mr. Mallet would make it), less than half a hundredweight extra in the pair of wheels will more than suffice to carry this slight extra load. But here Mr. Mallet soars away into the remotest realms of imagination and irrelevancy. "Then as to the carriages!" Just so, we came near forgetting them altogether, inasmuch as their weight bears no necessary relation to the width of gauge, since within limits they need be no wider on one gauge than on another; they need be no longer, and certainly no higher. "It was equally undeniable that the weights of any similar structures whatever vary as the cubes of their homologous dimensions, so the weights of the carriages will be as the cubes of the gauge;" and so, in this case, Mr. Mallet should have added, would their cubic capacity. But why increase this or their weights at all? Perhaps this omniscient authority will kindly tell us. But if the weight of the carriages did increase as the cube of the increased gauge, what would become of the axles? We have to go back to them. Where the 4 cwt. axle of the ordinary gauge is doubled in length, and thereby, upon Mr. Mallet's calculation, to be made to weigh either 25 tons or 32 cwt., whichever he prefers, it is still to be of but the same strength as the ordinary 4 cwt. axle. But we are now putting upon it a carriage of eight times the former weight, and here again we require eight times as much absolute strength in the axle. Clearly it must be made to weigh either 6,553,600 tons or 12 tons 16 cwt., according to which rule Mr. Mallet intends to abide!

Need we wonder that one speaker pointed out to Mr. Mallet that the Great Western engines, upon his calculations, would weigh at least 343 tons; or that another speaker said that, to maintain the extremely narrow-gauge doctrine, was to say that Pickfords could better carry on their traffic in costermongers' carts than in their present vans?

Mr. Mallet, the author of these "haevers," is understood to be one of the conductors of *The Engineer*.

ENGINEERS FOR INDIA.

We have so often written under a title somewhat similar to that given to the present article that it might almost be feared lest it should share the same fate as did the cry of "wolf" in the fable. This paper, however, has now attained a position peculiar to itself in this country as the representative of engineers and engineering works in the East Indies. We have purposely given all our support and encouragement to the Indian civil engineering service, whilst other journals have not ceased to cry it down, acting as we have done upon the convictions that abuse is not argument, and therefore but little calculated to attain its end, and that it was only necessary that the civil element should be largely increased in the Public Works Department, in order that its civil members might obtain simple justice, and a position and emoluments more nearly equal to those enjoyed by the military members of the establishment. During the present dearth of employment in this country, it would be worse than folly to try and prevent young men from earning an honest livelihood in an honourable service by endeavouring to depreciate the value of that service. If the pay under Government be smaller than is given to engineers by other employers, it must not be forgotten that the former service is sure and

* The 25-ton axle (eight times the diameter of the ordinary axle) would, according to Mr. Mallet's rule, be only strong enough to carry the ordinary load. On the wider gauge, however, the load would be eight times as great, and to carry this load the axle would have to be increased in strength eight-fold. As Mr. Mallet states that the strength of the axle increases only as the cube of the diameter, the axle required for the wider gauge would have a diameter equal to that of the 25-ton axle multiplied by 8, or 512. The sectional area and consequently the weight of this axle would be 512², or 262,144 times that of the 25-ton axle, its weight thus being 6,553,600 tons! or say about 170 ft. in diameter!

continuous, whilst the latter is at best uncertain. As an instance of this fact we may mention a circumstance which has recently come to our notice. A young engineer, in the service of the Bombay Government, who had obtained his appointment at one of the annual competitive examinations in this country, thinking to better his position, accepted an offer of employment under one of the reclamation companies that were started during the great speculation mania that occurred at Bombay a few years since. He managed to get free of his agreement with the Government, and entered upon his new appointment with increased salary, and, of course, a feeling of contempt for the service he had just left. A very short time afterwards came that fearful crash which brought ruin to so many families in Bombay; the reclamation works were necessarily stopped for want of funds, and our young friend was thrown again upon his own resources to seek employment elsewhere, and, perhaps, to begin life anew. Feign would he have returned to that service which he had but a short time previously thrown up, for, as he thought, something better, but he could not; the masters he had slighted cared not for the services of one who had already shown that he was prepared to leave them on the first offer of what appeared to be "something better." So our young engineer returned to England, only to find a similar stagnation of enterprise here, and to regret the hasty step which he had taken.

This is no fanciful picture, but a true and correct statement of facts. Indeed, we could give the name of the young man, but that were unnecessary.

Notwithstanding that twenty-four engineers were sent to India in July last, it has now been determined by the Indian Government to offer twenty-five more appointments for competition, at an examination to be held at the India Office in December next, and this, as stated in the advertisements, will not interfere with the examination to be held in the following July. Fifty appointments have thus been offered, in the Public Works Department in India, in the course of twelve months; and if this rate be continued—and, considering the present want of engineers there for irrigation, in addition to other Government works, there seems to be little doubt that it must be continued—the department will soon possess such a proportion of civil members as shall enable them to represent their grievances to Government, if, as a body, they have any, in a manner that cannot fail to command respect; if, however, the complaints of which we so often hear are in fact merely the results of unrewarded or rather, perhaps, we should say justly rewarded want of merit, the case is entirely different, and each one must be content to bear his own individual lot. One thing we must admit, and that is, that the pay is too small on first entering the service: let it be but raised to 300 rupees a month, and we firmly believe that the result will prove equally beneficial to the service and to the Government. There is also another want from which the department at present suffers, and that is an absence of any recognised status in society for its members. The remedy of this evil rests, we believe, very much with the members themselves, but a great boon would be conferred on them if the Government would but lay down some order of precedence to be observed when civil engineers, civilians, and military officers came together, allowing them to rank in some certain order with the others, according to their position in the Public Works Department. But one of the chief wants of the department in India is, as we have before pointed out, some association of its members to form out there a Society of Engineers, or to establish an institution on the basis of the Institution of Civil Engineers, in Great George-street. It is now some months since we first threw out suggestions of this nature, and find that it has, to a certain extent, been taken up in India, in a manner which has led to a proposal to form a "Bombay Association of Engineers." Perhaps, considering the extent of India and the distance between the capitals of the three Presidencies, it would be better that each Presidency should have a separate association of its own; but much mutual good would be obtained by the establishment of a certain connexion amongst them all, so that by regular intercommunication the knowledge and experiences of each institution would be so far communicated to the others. Governed by similar rules, and all having one and the same object in view, we shall hail with pleasure and satisfaction the news of the successful establishment of the "Bombay Association of Engineers," and hope soon to see such an excellent example followed by the establishment of similar institutions in each of the sister Presidencies.

THE HIGHLAND RAILWAY BRIDGES.

WE continue our illustrations of the bridges of the Highland Railway as designed by the engineer, Mr. Joseph Mitchell. That on page 321 is the Spey viaduct, with a principal span of 230 ft., the one, by the way, upon which an extended correspondence arose, not long after the construction of the plate-girders, between Captain Tyler, of the Board of Trade, and Mr. Fairbairn, the constructor. Although the girders were of the full strength corresponding to Mr. Fairbairn's practice, Captain Tyler took exceptions to them, and they were strengthened to meet his views. No question can be raised as to their sufficient strength now. The engraving on page 320 represents the Killcrankie viaduct, fully described in Mr. Mitchell's paper, which we printed in *ENGINEERING* of September 13th. We have engraved a series of views of the bridges upon this line, not because of any special peculiarities of their mechanical structure, but mainly on account of the fine character of the abutments and approaches; in short, the artistic qualities of their general design. For variety and originality, for pleasing outline and detail, and for their dignity and their harmony with the associations of the district traversed by the line, these bridges are admirable works in every respect. They have an artistic as distinguished from their merely material character, which is but seldom represented in the works of our railway engineers, and they are, notwithstanding, economical structures. They are well worthy the examination of the profession, and they will especially provoke a comparison with the hideous erections which have been carried out in some parts of the metropolis, and which outrage every principle of taste and every artistic aspiration of our time. We could especially wish that Mr. Mitchell had been the engineer of the Charing Cross and the London, Chatham, and Dover Railways.

LORD REDSDALE.

THE controversy between Lord Redesdale and Mr. Brassey, Mr. Bidder, and Mr. Sinclair has brought into painful prominence the angry inductions and treacherous temper of the noble chairman of committees in the House of Lords. The merits of the whole case may be even better gathered from the carefully written and dispassionate letters of "M." in our own columns of September 20 and 27, than from the correspondence in the *Times*. Lord Redesdale had accused the Great Eastern directors of swindling, Mr. Brassey of jobbing, and, by implication, Mr. Sinclair of dishonest conduct, upon alleged grounds which are now too well known to require repetition, although those who are still unacquainted with the case will find it fully stated in "M.'s" letter of a fortnight ago. Lord Redesdale has been compelled, publicly, to own that all his assumptions as to personal character were erroneous, although he has done so with a bad grace, and has involved himself in actions for slander brought against him by both Mr. Bidder and Mr. Sinclair. None who have followed the correspondence can have failed to observe how completely Mr. Brassey has maintained the position of a high-minded, honourable gentleman, capable of forgiving, while demolishing, the attack so inconsiderately made upon him.

Gentlemen of our profession can hardly feel themselves safe, after this, in giving evidence in Lord Redesdale's committees, and it remains to be seen whether the peers of Great Britain will continue to allow one of their body, who has so sadly yet clearly convicted himself of intemperate behaviour, to retain the important post which he now occupies.

NEWSPAPER POSTAGE TO AMERICA.

HERETOFORE, all newspapers, of whatever weight, have been posted to the United States for one penny each, two cents, equal to another penny, having been also collected there upon delivery. By the recent postal convention between the British and American Governments, the postage, twopence, must now be wholly prepaid on this side, and papers weighing over 4 oz., as *ENGINEERING* does, must pay twopence extra for each additional 4 oz., or fraction thereof. In many cases this would carry the postage of our paper to 6d., and in all cases to 4d., and, except to those who have paid for *ENGINEERING* in advance, we must now discontinue sending it, and request our American subscribers (in arrears) to obtain it from our sole American agent, D. Van Nostrand, 192, Broadway, New York, who is also authorised to receive the amounts due from them for subscriptions. Mr. Van Nostrand's weekly parcel of *ENGINEERING* is, we believe, now the largest of any English paper sent to America, with the exception only of the *Times*, the *Illustrated London News*, *Punch*, and the *Cosmopolitan*.

THE SWEDISH XV-INCH GUNBOATS.

WE some time ago mentioned in this journal that Captain John Ericsson had designed for use on the coast of Sweden some gunboats presenting many peculiarities of construction and arrangement, one of the chief of these being that their machinery was planned so that they could be propelled by either steam or manual power. Not content with designing these boats, Captain Ericsson has had one of them built at New York, and he intends presenting it as a model to the Swedish Government. Of this boat we propose giving some particulars.

The hull, which is 85 ft. long, 18 ft. beam, and 7 ft. deep, resembles that of an ordinary vessel with easy midship section and fair lines. The deck, like the hull, is composed of plate-iron, curved upward in the middle, and riveted water-tight to the sides of the latter. Thus the hull is, in fact, a close water-tight box, which may, if necessary, be submerged. On the top of this water-tight box is placed a raft formed of solid timber, 103 ft. long, 20 ft. wide, and of about 2 ft. mean depth, pointed at the ends like the monitors, the forward end being protected by 5-in. thick side armour. The raft projects 9 ft. beyond the hull at each end. The stern projection, as in the monitors, has been introduced for the purpose of giving absolute protection to the rudder and propeller; whilst that at the bow of the Swedish gunboat, beside protecting the anchor, as in the Passaic class of monitors, serves an additional and very important purpose, viz., that of protecting a small paddle-wheel or "training-wheel," by means of which the vessel is turned on her centre. The turret, supported by the raft to which it is firmly bolted, is placed a little forward of the midship section.

When the vessel is fully equipped for service, the raft is submerged, all but 9 in., at midships, thus offering a complete protection to the hull, rudder, propeller, and training wheel. The turret is stationary, it being intended that the boat should fight bow on, and, consequently, in order to expose the smallest possible surface to the opponent's fire, the turrets are made oval, the dimensions being 12 ft. wide by 19 ft. in line of the keel. The pilot-house, containing the steering-gear, is cylindrical, and placed on the top of the turret, as in the monitors; but the gunboat turret being stationary, its pilot-house, though placed in the line of the keel, does not occupy the centre. It is placed aft of the latter, thus affording ample space for the hatches by which the turret and hull are entered. The port is only wide enough to admit the muzzle of the 15 in. gun, and sufficiently high for ten degrees elevation. It is closed by a massive wrought-iron port-stopper, as in the monitors; but, in addition to this expedient for closing the port against the enemy's fire, a contrivance of a less massive character is adopted for closing the port against the sea. The turret is plated with 7 in. armour, and it will contain one 15 in. gun of the American pattern, this gun being, however, cast in Sweden, of Swedish iron.

As the turret is fixed, the pointing of the gun has to be effected by moving the boat itself; and to give the necessary handiness, the latter is fitted with a balanced rudder, and with a peculiar arrangement called a "training-wheel." This "training-wheel" consists of a paddle-wheel placed, with its axis parallel to the keel, in a kind of well about 4 ft. square formed through the overhanging portion of the raft at the bow of the vessel. The shaft on which this wheel is placed passes through a stuffing-box into the interior of the vessel, and is provided with gearing so that it can be worked by manual power. As the axis of the wheel is above the water-line, the action of the wheel, when caused to revolve, is to move the head of the vessel laterally, and, from experiments which have been made on a raft of the same size as the gunboat, it appears that the contrivance answers its purpose well. As the wheel may under some circumstances be wholly submerged, the floats are fitted with feathering gear, which causes them to pass edgewise through the water during the upper half of their revolution, and the immersion of the wheel will thus but little affect its action.

The machinery for the boat has been constructed at the Delameter Ironworks, New York, and a trial of it was made about three weeks ago, the "manual engine" being worked by some of the crew of the Swedish man-of-war *Norrköping*, which vessel is to convey the gunboat to Sweden. The steam machinery consists of a boiler 6 ft. by 8 ft. by 5 ft. 6 in. high, placed near the stern of the vessel, this boiler having a steam cylinder on each side of it. By these cylinders is driven a shaft extending across the back of boiler, and from this shaft the motion is communicated to the screw-shaft by bevel gearing proportioned so that the propeller makes two revolutions to one of the engines. The bearings of the screw-shaft are fitted with a number of steel rollers, and an arrangement of steel rollers is also employed to receive the thrust. A fly-wheel is provided to help the machinery over the dead points when it is being driven by hand power. The propeller is 6 ft. in diameter, and is entirely of wrought iron, the boss with the curved flanges for supporting the blades being shaped out of the solid. The blades are made of the famous "Washington" iron; they are $\frac{3}{4}$ in. thick at the boss, and taper to $\frac{3}{8}$ in. thick at the circumference.

When the vessel has to be propelled by manual power, the connecting-rods of the engines are disconnected from the crank-pins, and the latter are coupled to rods which lead forward to a series of vertical levers worked by the men. The levers are hinged at their lower ends to the floor of the vessel, and at their upper ends they each carry a cross handle, which can be taken hold of by four men placed in pairs opposite each other. The stroke of the handle end of levers is 32 in., this stroke being twice as long as that of the steam-engines. There are six levers placed in two rows, one row for each crank, and each lever is, as we have said, manned by four men. It is intended that the levers should be worked at 30 strokes per minute, and this speed of working was easily maintained during the trial, to which we have referred. This trial lasted for an hour continuously, and it was made on dry land, a friction dynamometer being applied to the screw-shaft to give the necessary resistance. A regular

trial of the boat afloat will, no doubt, be made before it leaves New York, and we hope then to say more about it. In the mean time we may mention that Captain Ericsson's object in fitting these boats with the machinery which we have described is to render them to a considerable extent independent of a supply of fuel, and thus to adapt them more perfectly for the peculiar service for which they are intended—a service for which they have been most carefully designed.

AUELING'S STEAM ROAD-ROLLER.

IN the course of our article on "Steam Road-rollers," on page 297 of our last number, we gave some of the leading particulars of a fine machine of this kind just constructed by Messrs. Aveling and Porter, of Rochester, for the borough of Liverpool, and we now publish, on the next page, a perspective view of this engine. As we stated in our previous article, the machine is really a modification of Messrs. Aveling's well-known traction-engines, the single cylinder and the driving gear being arranged as in those engines, but the construction and position of the wheels are altered to suit the work which the road-roller is required to perform. The principal dimensions of the machine are as follows:

	ft. in.
Diameter of cylinder	0 11
Stroke	1 2
Diameter of driving wheels	7 0
Width	2 6
Width from outside to outside of driving wheels	9 9
Diameter of leading wheels	5 0
Width	5 0

The driving wheels are of cast iron, and they alone weigh 6 tons each. The leading roller consists of a pair of wheels or rollers, each 2 ft. 6 in. wide, placed close together, these wheels revolving independently on their axle to facilitate the turning of the engine. This pair of rollers acts upon the road as a single roller 5 ft. in width, and smooths that portion which would be left untouched by the driving wheels. The leading axle is carried by a frame, or turntable, which bears against a number of cast-iron spheres, so that it can be turned very easily. This turning is effected by steering-gear, the arrangement of which can be readily traced out from our illustration. By the side of the hand-wheel by which the steering-gear is actuated is placed a neatly contrived indicator, which shows the steersman the precise position occupied by the leading rollers. The tank for the feed-water is cylindrical, and is placed directly over the turntable of the leading rollers. The total weight of the machine in working order is 30 tons, of which 11 tons rests upon the leading and 19 tons on the driving wheels.

As we mentioned in our previous article, to which we have already referred, some trials of this machine were made in Hyde Park last week, and it was found to do its work in a thoroughly satisfactory manner. The fact that macadamised roads should be compressed by the passage of heavy rollers over them before they are opened for traffic is gradually becoming generally acknowledged, and, this being the case, there is but little doubt that steam rollers, which can be worked at a greatly less cost than those drawn by horses, will soon become a necessary adjunct to road-making plant.

THE FRENCH EXHIBITION.

M. EUGENE LACROIX, the well-known scientific publisher, in Paris, has written us, requesting us to reprint (with corrections) a letter, which he was last week compelled to address to *The Engineer*, in consequence of a scandalous statement contained in a late number of that paper, reflecting upon M. Michel Alcan and himself.

MOSSIEUR.—On me signale une histoire assez édifiante que vous racontez dans vos colonnes, à propos d'un membre du jury des récompenses qui aurait profité de sa position pour se livrer à un petit trafic à son profit personnel, et qui serait descendu au rang de "Commis Voyageur Colporteur" (Bagman), pour imposer aux exposants qu'il était appelé à juger l'achat d'un exemplaire d'un ouvrage dont ce juré est l'auteur—livre dont vous indiquez même le prix, cinquante francs.

Jusqu'ici je n'ai rien à voir dans ce récit que j'ai tout lieu de croire authentique, mais vous ajoutez, "This gentleman is the author—as M. Lacroix, of Paris, well knows, of more than one edition of a work upon the textile manufactures."

Je ne comprends pas bien l'intention qui a dicté cette phrase, et quelques-uns de vos lecteurs ont pensé qu'elle pouvait être préjudiciable pour moi.

Parmi les membres du jury de la classe dont vous parlez se trouve M. Michel Alcan, auteur d'un livre sur les matières textiles.

J'ai effectivement trop connu ce monsieur que vous voulez bien appeler un gentleman, j'ai eu précisément avec lui un procès, et cela à propos d'un livre de 50f.—ouvrage dont je ne suis pas l'éditeur, et que, d'après moi, il a publié sans en avoir le droit, puisque j'étais l'éditeur d'une édition antérieure non épuisée.

S'il s'agit de ce livre, et votre article est assez transparent pour me le faire croire, je désire que vous sachiez bien que je ne suis pour rien dans l'exploitation que vous signalez, et tous ceux qui me connaissent savent que, loin de prêter la main aux exploitations de ce genre, j'ai toujours refusé, et je refuse encore, l'insertion de tout article payé, ou de tout article de complaisance, dans mes "Annales du Génie Civil" et dans mes "Etudes sur l'Exposition."

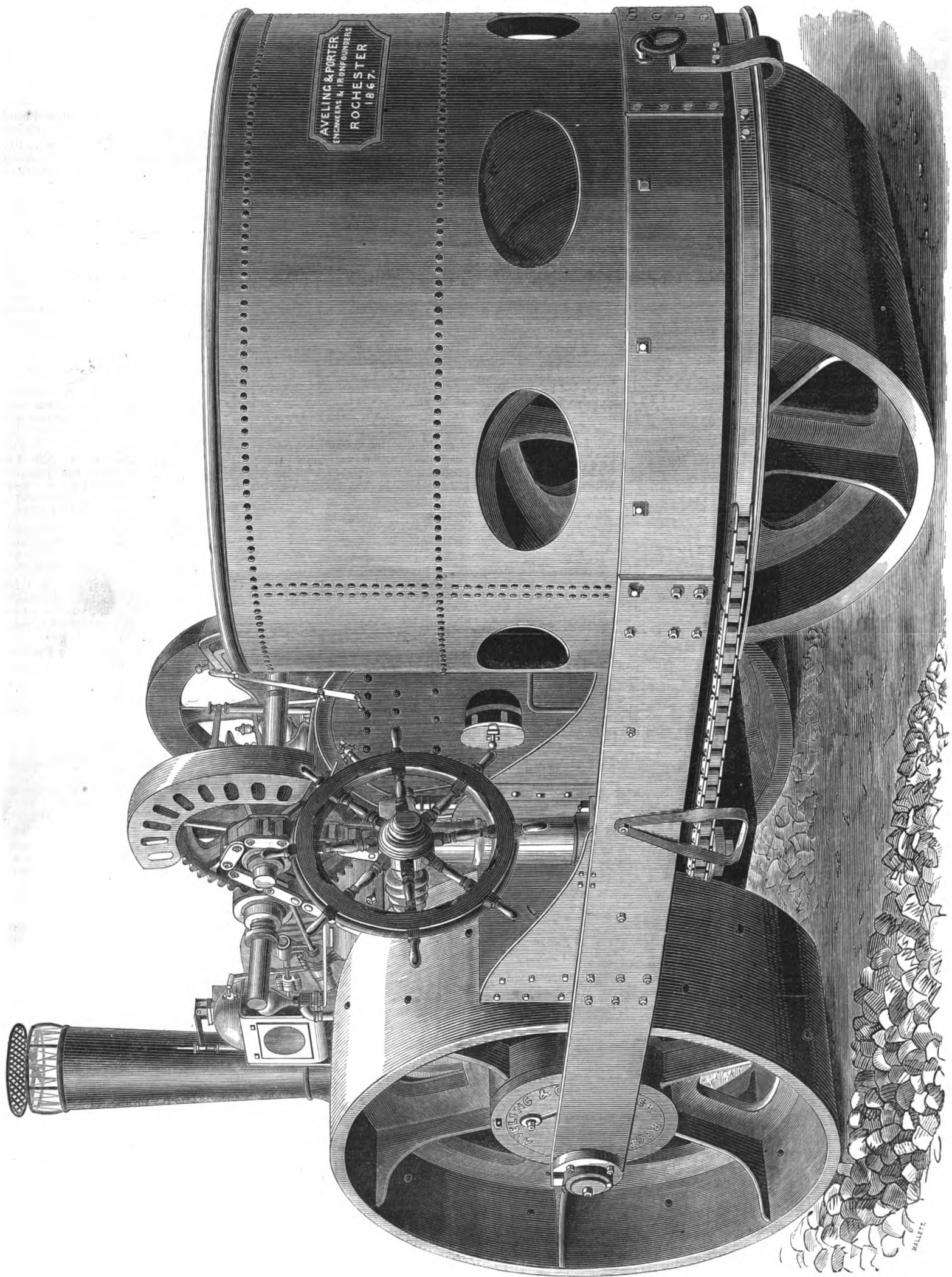
Il est aussi vrai de dire que, n'étant ni savant, ni professeur du Conservatoire, ni membre du jury, je suis forcé d'être au moins quelque chose "honnête et impartial."

Il paraît d'après votre récit qu'il est des auteurs et des éditeurs qui entendent le commerce autrement que moi. Ceci n'est pas mon affaire; mais je désire que vous annonciez à vos lecteurs que je suis complètement étranger à ce que vous qualifiez "little jobbing," ce qu'en bon français nous nommerions d'ignobles tripotages.

EUGENE LACROIX.

STEAM ROAD-ROLLER FOR LIVERPOOL.

CONSTRUCTED BY MESSRS. AVELING AND PORTER, ENGINEERS, ROCHESTER.

(For Description, see the preceding Page.)

PUBLISHER'S ANNOUNCEMENT.

Advertisements cannot be received for insertion in the current week later than 5 P.M. on Thursday. The charge for advertisements is three shillings for the first four lines or under and eightpence for each additional line.

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In consequence of a new postal convention between this country and the United States, the postage on each copy of this paper to America will, after the present week, be 4d. Subscribers who have not already paid in advance are therefore requested to obtain the paper through our sole American agent, D. Van Nostrand, 192, Broadway, New York.

MEETING NEXT WEEK.

SOCIETY OF ENGINEERS.—Monday evening, October 7, 1867, at half-past seven o'clock. Adjourned discussion on Mr. Pendred's paper on "Water Tube Boilers," and, should time permit, a paper will be read by Ewing Matheson, "On the Quality of Iron as at present used."

ENGINEERING.

FRIDAY, OCTOBER 4, 1867.

THE PROFESSION AT COURT.

BUT few in our profession have ever received the honour of knighthood. In one or two instances, however, this mark of royal distinction has been declined by engineers to whom it had been offered, and it appears to be the feeling that men distinguished by large mental endowments should be superior to a rank so liberally conferred upon provincial mayors and wealthy city aldermen. The ablest lawyers, however, take kindly to this mark of royal favour, and it may be almost said to be thrust upon them whenever they are raised to the bench, since the public, from immemorial custom, appear to believe that sound judgment cannot be given by anybody less than a knight or a baronet. If the distinction is intended, however, to bear any relation to the value of the services rendered by its possessor to the public, none better deserve knighthood or a baronetcy than certain of our engineers, and the honour just conferred upon (now) Sir John Brown naturally raises the question as to the principle upon which these dignities are conferred. We truly think that they are valued even in our profession, and that, where offered to gentlemen really worthy of them, they would seldom be declined. So far as we have heard, the honour conferred upon Sir John Brown has given pleasure even to engineers; not that Sir John is himself an engineer, but his pursuits are in their nature akin to engineering. None, we should say, would have had the distinction withheld; and yet we are unable to say precisely what Sir John has done more than other men—albeit that he has done well—to deserve it. We do not suppose that he was knighted because he has made a fortune, nor because he was formerly mayor of Sheffield, for this was some few years ago; and, except the Queen had visited steelopolis during his mayoralty, there would have been no case for knighthood merely because of this civic dignity. Nor can it be merely because Sir John has a great establishment, for in that case Robert Napier, and Titus Salt, and John Platt, and Mr. Houldsworth of Manchester, and half-a-dozen other plain gentlemen at the head of great works would equally deserve the distinction for the same reason. What one man in England has so large a business as Mr. Pease, of Darlington? True, he is of the good old Quaker stock, which will have nought to do with the vanities of title; but yet what an owner of mining property, what a coker of coke, what an ironmaster, manufacturer, and banker is Joseph Pease! It is not either

because Sir John Brown has made such good armour-plates, for so has Charles Cammell, and Samuel Beales, and Captain Ford, and William Clay. The *Times*, the other day, made out that rolled armour-plates had triumphed completely over hammered plates, and that Sir John Brown had been the first to successfully roll plates. Indeed, we inadvertently gave an apparent assent to this opinion; but the facts really are that the War Office still profess to find no substantial difference between good rolled and good hammered plates, and that armour-plates were first successfully rolled by Mr. Sanderson, at Parkgate. But we will ask no further, for we write in no grudging spirit, nor do we wish to appear ungracious.

Sir Hugh Myddelton received the honour of knighthood in his double capacity of civil engineer and "adventurer," and, we might add, that of a goldsmith. "Auld John Kennie," the great engineer that he was, was not knighted; but his son was. Sir Maro Isambard Brunel had the like honour; but his son, who carried out greater and far more useful works, although with some extravagance of outlay, died plain Mister Brunel. We believe the distinction was offered to and declined by both Stephensons; but Robert sleeps proudly in Westminster Abbey, and the greatest railway company in the world erected a statue to the father in its principal station. Sir John Macneill received a knighthood, and so did Sir Macdonald Stephenson, and Sir William Cubitt, the railway engineer (there were two knights of the same name, but in no way related to each other); and so did Sir Charles Fox, in his capacity, however, of contractor for the building of the Great Exhibition of 1851, and not as a civil engineer. Sir William Armstrong is another engineer thus honoured by his Queen, and Sir Peter Fairbairn (brother of another Fairbairn even better known) was knighted on the occasion of the Queen's visit to Leeds, during his mayoralty. One cannot but ask why the like distinction is not offered to those who have done even more in our profession and for the country than either of these gentlemen knights. We would not be presumptuous, but we think we carry the whole feeling of the profession with us when we say that he who now holds the first position in it, and to whose skill London owes that extraordinary wonder of our time, the underground railway, well deserves the recognition of her Majesty. And there is another gentleman, who perhaps stands at the very head of mechanical engineering throughout the world—one whose engines have given a speed and character to the ships of our navy possessed by those of no other nation, and who will soon complete the very largest and most powerful pair of screw-engines ever made, albeit that they are nominally rated as less by 200 horse power than those of some of our ships already afloat. And there is still another gentleman, who has given to the world the grandest discovery ever made in iron-making or steel-making—a discovery which is likely to yet render malleable iron an obsolete material, and which, in the opinion of that clear-headed Frenchman and political economist, Michel Chevalier, is worth more than all the gold discovered in Australia and California. We are, of course, unable to say whether John Fowler, John Penn, and Henry Bessemer, or either of them, would accept a knighthood were it offered them; but we are sure that a mark of royal distinction thus bestowed would excite no jealousy, no surprise; but, on the contrary, that it would afford sincere and general satisfaction, and be accepted in its real significance, that of a fitting compliment paid to the whole profession.

THE AGE OF STEEL.

THERE is everything to indicate that within a moderate period, and possibly within a few years, malleable iron will become an obsolete material. For every purpose to which it is now applied, steel will be yet found to be perfectly adapted, and to possess in a far higher degree all those qualities, not only of hardness and durability, but of pliability and malleability also, which now render iron the nobler metal of our age. The art of casting steel is now a century old—older, indeed, than that of puddling iron—but it is only within a few years that those greater improvements which now so clearly indicate the wonderful future of steel have been made. No one knew twenty years ago how to cast a steel ingot of even a hundred-weight, whereas it is now practicable to cast one of fifty tons, and even larger blocks could be made, if wanted. It is but twelve years, this very month, since Mr. Bessemer discovered how to make steel, cheaply and in large quantities, direct from cast iron, and it is hardly six years since it was found that this steel could be perfectly adapted to all the requirements

of railway bars and boiler plates, which, besides having hardness and strength, must have toughness as well.

The art of casting steel to shape, and so as to be used without subsequent hammering, is nearly as recent, and not only railway wheels, but most complicated castings, such as locomotive cylinders, are now cast in steel. The possibility of giving to steel of enormous strength a very high degree of pliability is shown by the improved steel wire now made and used for steam-ploughing ropes. This has a strength of from 160 tons to 175 tons per square inch of actual section, 176 No. 14 wires having a total section of one square inch, while each wire will bear from 2000 lb. to 1 ton breaking strain. Yet it will bend around a pipe-stem, and the ropes made from these wires run readily around 4 ft. or 5 ft. drums, coil perfectly, and last for a long time. It is requisite now to obtain the same toughness or pliability in large masses of steel, and so much has already been done by the use of manganese in its combination with iron, and so much is believed by the ablest metallurgists to be still possible, that it involves no great stretch of confidence to believe in the early applicability of steel even to armour-plates, which afford, perhaps, the best measure of its strength under impact. And we may be sure that the steel which will serve for armour-plates will answer every other purpose for which malleable iron is now used, while it will possess much greater absolute strength, and will, there is good reason to believe, be actually cheaper in first cost.

THE GUN AND PLATE QUESTION.

EVERY aspect of the broad question of ordnance or armour has changed so rapidly that it requires constant attention and a good memory even to understand its present position. It is almost beyond doubt, also, that the question must pass through further and even greater changes, some of the elements of which are already discernible. No thinking man can approach this vast question without feeling more than ever how very lately it was when we were first hearing of explosive shells, rifled ordnance, and armour-plates for ships of war, and how very rapidly the whole subject of naval warfare has been reduced to a question of mechanical engineering.

A very few years ago, it was considered very doubtful whether an armour-plate could be made to withstand the fire of the Armstrong 110 pounder, fired with 14 lb. of powder. The 4½ in. plate was soon produced, but it was then a question whether any ship could be made to carry it. At last, however, Sir John Pakington and Mr. Watts gave us the Warrior, and what Englishman was there who was not proud of that noble vessel, now, alas! known to be a huge mistake, one of the weakest and most useless ships of our newer navy. We need hardly refer to the rapid changes which followed—changes in guns, in projectiles, in armour-plates, and in entire ships, nor how Major Palliser, by his one terrible discovery of pointed chilled shot, undid an amount of work which it had cost us millions to do.

These changes have brought us the knowledge of certain facts, some of which we may summarise here. We now know that it is possible to make a target, leaving its weight for a moment out of consideration, which shall resist any and every ordnance whatever, present or prospective, since we know that the resistance of targets may be infinitely increased. This may be done by adding to the number of plates, with or without intermediate supports upon Mr. Chalmers's plan, and by providing corresponding backing. That a single impenetrable plate may be made we will not say, but we now have plates 9 in. thick proved of admirable quality, leaving nothing to be desired on that score; we have seen a 15 in. plate, of which there is reason for believing the quality to be equally good, and it is known to be only a question of size of furnaces and mill power to produce still thicker plates. As for carrying such heavy armour, we are already building the Hercules with no less than 11½ in. of total thickness of iron in the sides of her central battery, and as she is but an enlarged copy of the Bellerophon, we know already, from the extraordinary success of that vessel, that the Hercules will be a buoyant and most handy ship. We are to remember that the total weight of armour is exactly as much a question of superficial area as of thickness, and that if we can diminish the exposed area by, say, one-half, we can at once double the thickness of our armour without adding in the least to its weight. We know that Mr. Reed is seeking, with his usual ability, to lessen the exposed surface and to increase the thickness of his armour up to absolute impenetrability by any guns yet proposed, to say nothing of the guns actually in use;

and we know how Mr. Bourne has shown that monitors may carry 2 ft. of solid armour, and twice that thickness of backing.

But if we build invulnerable ships, so will other nations with whom we may some day be at war, and we may be sure that in war we shall not rest content with the security of our own ships, if we can find no way to send our enemies to the bottom. Naval officers and sailors are very bloodthirsty in action, and our enemy might as well be in the moon if he is go about, like ourselves, in ships which can neither be boarded, nor penetrated, nor sunk. The captains will be calling out, by-and-by, for removable armour, so that they may hail the enemy with a "Reef your plates, you beggar, and fight!"

As the case now stands, the gun is the weakest point in our armoured ships, meaning, of course, those of the best type. We must have better guns, or anything like real naval warfare will soon become an impossibility, greatly, no doubt, to the gratification of the Peace Society, but not to that of hostile nations and crews, desirous of cutting each other's throats. Neither our own nor the American gun will satisfy the condition, nor any gun upon the principle of either. We have already reached the limit of unburstability, in our own 13.3 in., if not in our 9 in. gun. Neither of them can burn half the powder requisite for the work we wish them to do. The American 15 in. or even the 20 in. is little better, if indeed it be even as good, not because it is of cast iron, which will burst all at once when it does go, for it could be made also in wrought iron and steel. Its fault is that, being a smooth bore, it can only fire round shot, and this, whether of cast iron, chilled iron or steel, will only penetrate iron when fired with very heavy charges, which, again, overstrain the gun, so that it becomes no safer or more durable than our own. The 15 in. Rodman penetrated the 8 in. target on Wednesday week, but only with 100 lb. of American powder, equal to about 83 lb. of our own. But so will our 9 in. guns, firing Palliser shot, with less than half this charge, so that there is no good in employing a 20 ton gun to do what can be done with one of 12 tons. For propelling a shot of given weight, at a given velocity, say a 450 lb. shot at 1500 ft. per second, the large smooth bore and round shot has the advantage of a larger driving area on the shot for the powder gases to act upon, and thus the strain per square inch is less. But, for penetration, the round shot is the worst possible, and with the same strain per square inch in a smaller-bored gun a pointed rifle shot of less weight and at less velocity will easily do the same work. Can we not have a combination of *both* systems?—one in which a long pointed rifled shot of chilled iron, a shot weighing half a ton or a ton, for that matter, shall be impelled by the action of the powder gas on a piston or base of twice or even three times the diameter of the shot, and presenting, therefore, four or nine times its sectional area. Only in this way can we hope to obtain low-pressure unburstable guns, which shall, nevertheless, fire the very heaviest shot of the very best form for penetration, at the very highest velocities.

THE RANSOME STONE PROCESS.

ALTHOUGH artificial concrete was known to and used by the Romans, and long ago by the French engineers, its general use in England dates back but a comparatively few years. Could we but know the cost of the cutting and fixing of natural stone in the foundations of the great works of Smeaton's, Rennie's, Telford's, and George Stephenson's time, we believe the amount would be startling even to engineers, who are generally unmoved by any statement or estimate of cost, however great. Speaking seriously, and with every regard for strict fact, we believe the former ignorance of and subsequent unbelief in concrete, on the part of English engineers, have added many millions to the cost of our public works. Now, of course, we understand its qualities and value, and we can hardly use too much of it. We know it to be virtually a liquid stone, which we can cast to any shape, in any situation, on dry land or under water, and to any size, and which will set rapidly, and become, practically, natural rock, as if moulded by nature to the precise requirement under which it is employed. We are, and we must own that we are, behind the French in many things. Their chemists have not been greater than ours. For their Lavoisier, and a score of less eminent names, we have our Dalton, our Davy, and as many others as they. But as a people, we English do not reason so rapidly and so profitably from induction as they. It occurred

much earlier to the French mind than to ours that all natural stone was concrete, grains of silicious, argillaceous, or calcareous matter, united by a cementing substance. The French engineers knew that they possessed artificial cements or mortars as tenacious as any found in nature, and they saw that with these they could make stone *in situ* as from a liquid, instead of seeking, and hewing, and transporting monoliths at and from a distance. For sea-walls and breakwaters, engineers now make nothing of 25-ton blocks, this being about the minimum weight which will resist, unmoved, the fury of an Atlantic storm; and Mr. Stoney, of the Ballast Board, Dublin, is contemplating the use of single blocks of 300 tons' weight, a description of which he will give to the Institution of Engineers in Ireland, and which we trust to be able to reproduce in our own columns.

As with concrete, so with Mr. Frederick Ransome's wonderful artificial stone, that made by his *new* process, patented in April, 1861. Our engineers do not yet fully understand its merits, and are losing time, and, we might almost say, misapplying money, while waiting to learn what they ought to know of it already. It does not require a century to test a stone. Chemistry has taught us the exact nature of the atmosphere and other agencies which act to destroy it, and how to prepare, and concentrate, and apply chemically like agencies direct, so as to effect in an hour, or a day, or a week, what in the natural course would follow only in a century. We know that the new stone has successfully withstood every test which chemistry has suggested as resembling any action of the atmosphere, and there is besides a considerable experience with the stone, already in practical use in the most exposed situations. As for its strength, that is a matter to be ascertained by a simple mechanical test, and it is accordingly found that even comparatively newly made artificial stone is from three to three and a half times as strong as Bath stone (see our last volume, p. 672).

We shall expect, therefore, to hear of the rapidly extending use of a stone possessing such extraordinary advantages in its manufacture. Mechanical engineers everywhere should obtain the materials, and make for themselves, *in situ*, all bed stones for steam-engines, steam-hammers, and heavy machinery, now put in at such great cost. Bolt-holes are moulded in this stone by setting wooden cores merely at the exact distances required, for the stone neither shrinks nor swells in hardening, and no allowances are therefore required. Civil engineers, who may desire to emulate the admirable taste shown by Mr. Mitchell in his noble bridges and bridge abutments upon the Highland Railway, will find the new stone the most readily adaptable to all the purposes of ornament of such works. Builders should be made to understand its great merits; and were the building journals less taken up with mediævalism, archæology, and *dilettanteism*, and more with the practical treatment of great and important questions of structural improvement, the knowledge of the qualities and mode of manufacture of the new stone would by this time have been far spread among a class of men who are to a great extent ignorant of many of the most important matters of construction. It should not take a lifetime, and a great and increasing waste of capital, to learn the value of a discovery which competent authorities have long since stamped with their seal of approval, as one of the most valuable, as it is one of the most beautiful, in the nineteenth century.

MOUNTAIN LOCOMOTIVES.

ADHESION is to the locomotive what a firm foothold is to the cart-horse. Like the horse, too, this adhesion is obtained in virtue of its own weight. An imponderable horse, if we can imagine such an animal, could get no foothold upon any ground whatever, just as an imponderable locomotive would have no adhesion. But while we cannot place the load upon the horse's back, unless, of course, it be a light one, we can load the locomotive to any amount that the rails—corresponding to the road over which the horse has to work—can bear, and 75 lb. steel rails, laid on sleepers 2 ft. 9 in. apart, will bear a great deal. The horse has to carry his own weight, and that of any load his master may place upon his back, upon his four hoofs, two only of which, in walking, bear upon the ground. But all the wheels of the locomotive, so long as the springs are elastic, are always bearing upon the rails, and we may have almost any number of wheels, so that they are grouped, four, six, or eight together, in swivelling steam-bogies, or bogies having their own cylinders, working parts, and valve gear. This steam bogie system affords the whole solution of the problem of exceptionally steep gradients. Our engineers have been seeking to manufacture adhesion artificially by

means of a host of devices, such as the gripping of a mid-rail by spring pressure, the plentiful use of sand, grooved rails, grooved tyres, even magnetised tyres, and other expedients, all either mechanically objectionable or unavailing. We regret to speak as we are compelled to do of the mid-rail. We know how Mr. Fell and Mr. Alexander have worked at the engine to simplify it as far as such a hopelessly complicated engine can be simplified, how Mr. Brunlees has engineered the Mont Cenis Railway upon this system, and how Mr. Brassey has given the scheme, in his usual spirited and generous manner, that material support which is the life-blood of every undertaking; but we cannot resist the fact of the future, already plainly discernible to many, that the whole contrivance must be abandoned. It is open to fatal objections, which we have before analysed, and it does only what can be better done by simpler means.

It is singular, that while the problem of steep mountain railways has been so long before our profession, so few have thought of taking advantage of the adhesion due to the *load* as well as that of the engine. Let the goods and passengers be placed directly upon the engine—not, of course, an ordinary locomotive, but one properly made to receive them. The engine would then have nothing to drag behind it, although its adhesion would be sufficient to enable it to take a load of nearly or quite its own total weight up 1 in 12. There would be a saving, too, of dead weight in the carriages; for while a railway-carriage, accommodating twenty-four persons, may weigh 5 or 6 tons, less than one-half this weight, applied in fittings to the engine, would provide for them equally well. We have often suggested this system, and we find that Mr. Fairlie had also hit upon it some years ago. We shall give, next week, a drawing of one of his engines, designed upon this principle of utilising the adhesion of the load. M. Flachet proposed, also (in 1859), to do this, but in a different way, by providing a huge boiler, with about 4000 square feet of heating surface, upon a carriage having cylinders and working parts to work up its own adhesion, and by leading steam through jointed pipes to cylinders fitted to each of the double bogies of the carriages to be drawn, each carriage working by its own adhesion, instead of being drawn from the boiler-carriage. Our own idea is to make a framework of, say, 30 ft. in length, to support it upon a swivelling steam bogie at each end, to place the boiler at one end, and to arrange the passenger compartments or goods space along the framing itself. Each bogie would have four or six coupled wheels, according to the weight to be carried, and as the wheel-base of each bogie need not, with 3½ ft. wheels, exceed 7 ft. 6 in., each would work round even two-chain curves, and it is well known that the longest double-bogie carriage, on the American plan, will go safely wherever either of its bogies will go singly. In the streets of the American cities, the long carriages, 40 ft. to 50 ft. long, are drawn by horses around curves of less than two chains radius, the flanges, however, and not the tread of the wheels on the outside of the curve, taking a bearing upon a flat surface of iron laid to receive them.

This system of utilising the adhesion of the load, carrying everything in fact on the engine itself, would no doubt be adopted if it were only patented, and some one was thus interested in working it commercially. As it is, some of the details are patented; but as the system as a whole is open to the free use of all, it may, paradoxical as it will appear, be a long time before any one has the courage to take it up and work it out.

INVENTION.

THE young gentleman who, correctly educated at a proper "establishment," passes into the office of an engineer—civil or mechanical, for it matters little which—is soon made to feel that "inventing" is an ignoble occupation, much like that of making verses or writing cheap novels. It is quite enough for the best efforts of a lifetime to learn to practise correctly what has been already invented. The inventor himself, from a boy, is an odd, abstracted being, whom few can understand. Like the discoverer of the greatest metallurgical process of the present age, he may get the nickname of "old scientific" among his school-fellows. All deep thought abstracts us from those who think but little, from those who are prone to believe that all material affairs move in obedience to fixed laws which none of us can greatly change, or modify, or adapt to new purposes. And yet it is invention that has made England what she now is, not but that industry, perseverance, commercial honour, and enlightened statesmanship have greatly contributed to our prosperity. And there is nothing which is now

more wanted than another great invention, which, like that of railways, shall change the whole condition of our commercial affairs, and put new life into trade. It may be said that we can have only so many inventors—that they cannot be created any more than philosophers or poets. But we have no measure of the latent capacity for invention that exists in the human mind, and no clear conception of the fields of future discovery. It is but by groping that we learn what is and what is not possible, and there are always possibilities which we overlook, and which will be discovered by those who come after us. There are but few, and they are our greatest and truest geniuses, who can invent or discover beneficently, and let every one accord to them the deep respect they deserve. Invention is not a trade to be learned and practised by rule, nor is it a pastime to be pursued for the sole amusement of the inventor. It is one of the solitary and holy walks of thought, beset with infinite dangers to the inventor himself, but from which mankind derives its greatest material blessings. As the genius of literature was stimulated in the time of Pericles, so is that of invention now. Never was invention more in demand, and the real, persistent inventor, who stands by his schemes and sees them through all the perils of their babyhood—and these are many—has everything to hope for. He need have no fear of the abolition of patents, nor of any application of the sophistries of Sir William Armstrong, who, enjoying the reputation of an inventor, is nevertheless one of the natural enemies of invention. It is now well known to be indispensable to the success of an invention, as much as to the training and cultivation of a child, that its parent should have the sole control of it for a limited period. We could point now to inventions of great promise, having, apparently, all the elements of success, which are nevertheless pining because they are not patented, and thus have no one to look after them. Indeed the case of an unpatented invention is well nigh hopeless, until perhaps after the inventor has gone down to his grave, possibly with a broken heart. It is now well enough understood that it is only with the protection of a "patent" (although that harmless word, meaning only "open," is objectionable as smacking of monopoly) that any invention can be expected to thrive; and when England, the birthplace of inventions which have regenerated the whole world, once turns the best offspring of her genius adrift to perish by neglect, her greatness is forever gone.

SINGLE-CYLINDER LOCOMOTIVES.

TREVITHICK's first locomotive, made at Merthyr Tydfil in 1803, and which was worked for two years at and near the Pen-y-darren works there, had a single cylinder only, of $4\frac{1}{2}$ inches bore and $4\frac{1}{2}$ feet stroke. Messrs. Neilson and Company, of Glasgow, made a few single-cylinder locomotives several years ago for collieries. These worked with tolerable success, although, like the famous "donkey injector," they often required a little coaxing to start them. Mr. Makinson, in the course of his investigations into the subject of counterweighting locomotives has, more lately, renewed the proposition for single cylinders, and he raised a lively discussion, for the most part against his views, at the Institution of Civil Engineers. If a single crank could be always started off, even when "hanging on the centre," single-cylinder locomotives would have much to recommend them on the score of simplicity and accessibility. Double cylinders were once thought necessary for steam ploughing and traction engines, but the best makers now prefer single cylinders, and obtain from them perfectly satisfactory results. In the case of a locomotive, however, as in that of a steam-vessel, absolute certainty in starting is a matter of the very utmost importance, and no question of simplicity of parts must be allowed, for one moment, to hazard this certainty. Once started, a single-cylinder locomotive, like a single-engined steamship, will, of course, run perfectly, since the engine and its train form a great reservoir of momentum, moving at the speed of the periphery of the driving-wheels, and, therefore, exactly equal in effect to a fly-wheel as heavy as the total weight in motion. In the case of a steamship, although the maximum speed is less, the weight in motion is immensely greater, often several thousands of tons, and, in the case of the Great Eastern on her full displacement, 25,000 tons. But all this does not lessen the seriousness of any hitch in starting, and he will be a clever engineer who will first show how a single-cylinder locomotive may be always started with certainty. Even could this be managed, single cylinders would still be open to one if not two objections. Frequency of discharge of the steam up the chimney

is an important condition of good draught. If all the steam passed through the cylinders in an hour were sent up the chimney in a single blast, or in even a hundred and twenty puffs, one every half-minute, it would have but little effect on the fire. It was this infrequency of discharge that made the first blast, that of Trevithick's engine, and the blast pipes of Hedley's and, after him, George Stephenson's earlier engines, so inefficient; and it was to the greater frequency of discharge in the short-stroke and less heavily loaded passenger engines that made the blast tell so distinctly upon their performance. Single-cylinder locomotives would send their steam up the chimney but half as often, although in twice the quantity at each discharge, as ordinary engines; whereas the more nearly the blast is continuous, the better it is.

It may be questioned, too, whether, from the greater irregularity in the application of the power, expansion could be carried as far, and thus with as much economy of fuel, in single as in double cylinders. Our own opinion is that it might; but we are aware that not all will agree with us. The Corliss and the Allen single-cylinder engines work with the utmost regularity when cutting off their steam earlier than is ever attempted in locomotives. And, as we have shown, the "fly-wheel" of a locomotive is its own weight and that of its entire train, and if it took steam on but one stroke in six it would not, probably, be found to work as unsteadily as any ordinary engine not properly counter-weighted.

To start single-cylinder locomotives off their centres, it has been proposed to employ a small donkey-engine, having a grooved wheel, which might be pressed against the flange of the trailing-wheel. A 6 in. cylinder, 6 in. stroke, a grooved wheel 6 in. in diameter, and steam of 100 lb. would, if pressed sufficiently tight against the flange of the trailing-wheel, exert a propelling force of 1800 lb., enough to start and to keep in motion any passenger train and moderately heavy goods trains. But such a contrivance, although not impracticable, and although in nine cases out of ten it might not require to be used at all, would involve the use of an additional starting and reversing gear, diminutive of course, yet demanding attention nevertheless. It is probable, too, that its working would not be attended with greater inconvenience than that of a sand-box, although that would still be required. Some pushing locomotive engineer may yet try the experiment, and let us know the result; for even an occasional failure is better than stand-still engineering, of which we are just now having so much. In place of the pair of 16 in. cylinders, let them try one of $22\frac{1}{2}$ in. diameter.

SMOKE-NUISANCE INSPECTION.

IN Maiden-lane, Strand, and near where that once-famous jurist, the Lord Chief Baron Nicholson, held his nocturnal court, is an ironmonger's shop of decent but not imposing appearance. In its window may be beheld the usual assortment of bottle-jacks, flat irons, beer-taps, cork-screws, mouse-traps, brad-awls, and other ferromongery common to such establishments, all, we have no doubt, of excellent quality, and sold at the very lowest cash prices consistent with a reasonable profit. The individual, we beg pardon, the professional gentleman, who minds this unobtrusive shop is Mr. Sandison (we might as well, perhaps, add "C.E.," as the initials cost nothing and go a long way), her Majesty's inspector of smoke nuisances for the metropolitan district. Mr. Sandison, who is occasionally, if not always, attended, in his official capacity, by a special policeman, has the right, after a complaint has been lodged with the police, to enter upon any premises named in the Act, and practically to enforce its fines and penalties wherever and whenever, in his judgment, its provisions against smoke have been transgressed; and from his judgment there is no appeal. The definition of smoke, in the meaning of the Act, is, of course, a matter of eyesight only, and we believe Mr. Sandison possesses a power of vision of unquestionable force and almost microscopic minuteness. Indeed, we believe he sometimes sees smoke where others think there is none to be seen; but then it is his business to see it. Mr. Sandison, although eminent as an ironmonger, and thus, no doubt, conversant with smoky chimneys, gives no advice that we know of as to how to suppress or prevent smoke where he finds it and fines it. That is the smoker's own business, not his. His duties are detective only, and not advisory. One cannot but admire, therefore, the wisdom of the Act, which empowers Mr. Sandison to enter wherever he pleases, since, although it is no business or, at any rate, no concern of his what goes on inside a factory or a boiler-house, but only what comes from the chimney aloft, and which he could best see a

quarter of a mile off, his presence, supported by that of his faithful policeman, sustains the majesty of the law, and may be taken as a caution equivalent to "Smokers, beware!" We believe, however, that Mr. Sandison has the power to decide, not only what chimneys do smoke, but also what furnaces are "so constructed as to consume their own smoke," and we believe that there are furnaces which do meet Mr. Sandison's approval, and that if these do smoke a little it is no matter, or, at least, that Mr. Sandison is not implacable, and will not wantonly make an example of their owners.

It strikes us that the importance of the smoke question, one with which so many of our very ablest boiler engineers, furnace-builders, and chemists even, have found themselves unable to deal as satisfactorily as could be wished, demands that a metropolitan smoke "inspector," or detective, should be a professional gentleman, having greater claims to the confidence and respect of the numberless involuntary transgressors of the Smoke Nuisance Act than any ironmonger or other petty tradesman, however much he may be respected in his own parish, and however excellent and cheap may be his goods, and however civil and attentive he may be to his customers. Can we not have an engineer?

ARTIFICIAL GRINDSTONES.

MECHANICAL engineers have, as yet, little idea of the extent to which artificial grindstones are being made by the Ransome process, nor of their superior quality to the best stones from that vast grindstone quarry, Gateshead Fell, in Durham, or that other source of supply to the Sheffield grinders, Wickersley, in Yorkshire. It is the peculiarity of the Ransome process that any fineness and sharpness of grit may be produced, according to the materials selected for making the stone. The sharp, clean, and well-dried sand, when made slightly cohesive with the gelatinous silicate of soda, is pressed together in the moulding-boxes under an almost perfectly uniform force, and the subsequent saturation and induration of the mass, by means of the solution of chloride of calcium, goes on with absolute uniformity, so that the grindstone, if the stone be moulded as such, is of absolutely uniform texture. It has no spots, hard or soft, but is all alike, and may be ground away, down to the spindle, and be found unvarying. Anything like vents or flaws, often enough found in Gateshead Fell or Wickersley grindstones, is impossible from the very process of manufacture. These stones can be made also of any required and regulated degree of hardness to suit the particular purpose for which they are to be used, and they can be made of any dimensions whatever, no matter how large or small, and at a cost no greater than that of natural stones. When we speak of cost, we refer to the selling price; for the prime cost of making artificial stone, from loosely running sand, is less than that at which it is possible to quarry and trim natural stone. When, as must yet be the case, only artificial grindstones are employed in all grinding operations, and a great market is thus made for them, the artificial stones will be much the cheaper in first cost.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.—The first meeting of this society for the present session will take place on the 9th instant, when Mr. B. Haughton, vice-president, will take the chair at 8 P.M. The following gentlemen were re-elected at the last general meeting to serve on the council: Mr. G. Eedes Eachus, as president; Messrs. B. Haughton and W. Forsyth Black, as vice-presidents; Mr. Frederic H. Roberts re-elected as hon. secretary; and Mr. G. J. Crosbie Dawson, as hon. treasurer. Members of the committee: Messrs. F. E. Cooper, R. M. Bancroft, W. Meakin, J. B. Walton, and W. Rutt. Arrangements have been made for the members to visit various engineering works during the recess. The last of these visits will take place on Saturday, the 6th instant, when it is proposed to inspect the Abbey Mills pumping-station for the Metropolitan main drainage by permission of Mr. Bazalgette. Members and their friends are requested to assemble, at 3 P.M., at the Stratford Bridge Railway Station.

COAL IN THE CHINA SEAS.—The consular agent of France at Formosa has reported the existence of bearings of coal at Ponghou, the principal island of the Pescadores group, between Formosa and the coast of China. The island of Ponghou possesses a port named Nabung, with a good roadstead for all weathers, even in case of typhoons. The only coal bearing yet discovered exists at the northern extremity of the island, but it is considered probable that coal will be found in all the sub-soil as well as in the other islands of the same group. No explorations have yet been permitted by the Chinese, so that the coal found has at present been only obtained from the surface of the soil, where it is of somewhat inferior quality. The soil of Ponghou also contains iron minerals.

LYNN DOCKS.—A commencement has been made with the long contemplated docks at Lynn. The chief portion of the land required for the works has been purchased or arranged for, and the excavation of the diversion of the Fisher Fleet is well advanced. Mr. Brunlees is the engineer engaged.

COAL RESOURCES OF INDIA.

We have on more than one former occasion, but more particularly in our articles relating to the Indian railways, referred to the important bearing which good serviceable coal in the immediate neighbourhood of those lines of communication must ever have, so long as coal continues to be the principal agent for the generation of steam in locomotives, upon the successful and profitable working of them. It is our intention now to lay before our readers some account of the locality, extent, and composition of the coal at present raised in the several localities within our Indian empire, where it has hitherto been discovered. The following particulars have been previously published in various numbers of "Selections from the Records of the Government of India," "Memoirs of the Geological Survey of India," and finally in a recent publication by Dr. T. Oldham, Superintendent, Geological Survey of India, in response to a return called for on the subject by the Secretary of State for India.

Viewed as a coal-producing country, it may fairly be asserted that the British territories in India cannot be considered as either largely or widely supplied with this essential source of motive power. Extensive fields do occur, but these are not distributed generally over the districts of the Indian empire, but are almost entirely concentrated in one and that a double band of coal-yielding deposits, which, with large interruptions, extends more than half across India from near Calcutta towards Bombay. This band extends throughout about 5° degrees of latitude, that is, between the 20° and 25° parallels of latitude. All the country lying to the south of the 20° parallel, and all the country lying to the north of the 25° parallel up to the foot of the Himalayas, with the exception of the widely detached coal-beds of Eastern Bengal, Assam, and the Khasia hills, and the poor coals of Tenasserim, presents, so far as those portions of the country are known geologically, either no probability whatever of any deposits of coal being found within their limits, or if coal does exist, it can only be expected to be found at such a depth below the surface that it could not be profitably worked or economised. As British India stretches from 8° north latitude to 35° or 36°, or through some 28°, the very local disposition of its deposits of coal becomes evident; and it would seem that they are so far removed from several of the railway systems of India as to preclude the hope that such lines could ever profitably employ the extracts from those beds as fuel, for they could be more cheaply supplied from England, the cost of land carriage on the one hand being so much more expensive than the freight by sea on the other.

The geological survey of India has not yet, it is true, carefully examined and searched the whole empire, but detailed examinations have been made of a very large portion of the known coal areas. The memoirs of the Geological Survey of India contain the following special reports, besides the more general descriptive notices, viz.: on the Coal and Iron of Cuttack; on the Talcheer Coal-field; on the Khasia Hills; on the Nerbudda Valley Fields; on the Raneeunge Coal-field; Mineral Statistics, Coal, &c.; the Coal of Assam; and the Jherria Coal-field; whilst reports on other coal measures have been separately published. Many of the examinations hitherto made have not been very complete, owing to the want of trustworthy maps, and no estimate has been attempted to be made regarding the actual supplies of fuel available in the separate districts or fields, in consequence of the absence of detailed sections of sinkings or workings.

Up to the present time it may be said that little more than surface workings have been carried on in India. The deepest pits there scarcely exceed 75 yards, while certainly one-half of the Indian coal, used up to the present date, has been produced from open workings or quarries, in which the coal has been worked like any ordinary stone. In parts of the Raneeunge field these open workings are of marvellous extent and size, covering hundreds of acres.

Many causes have combined to lead to this mode of working. Cropping out at the surface with a very small dip, and, in most cases, with a very limited covering of clay or rocks, the valuable mineral could be removed at a very small cost. No expense was incurred for lights; drainage was easily and cheaply effected; all the coal was obtained, and the heavy waste incurred in cutting or hewing brittle coals, such as are most of the Indian coals, was avoided. But even more than all these considerations, the facility of obtaining labourers who would work in the daylight, and the difficulty, or even impossibility, of procuring those who would work in a pit, combined with the ease of inspection and measurement in the one case,

and the cost and difficulty in the other, all led to the vast extension of open-work quarrying of coal, and, consequently, to the economy with which the mineral could be obtained and sold. This system is, however, now rapidly disappearing. Much of the coal accessible in this way has been removed, while at the same time the managers and proprietors are daily becoming more alive to the injudiciousness of exposing valuable seams by these diggings towards the outcrop. Every year is also adding to the number of labourers, and also of the tribes or castes to which they belong, who will work underground.

Even in the only Indian coal-field which has as yet been worked to any extent, namely, Raneeunge field, very much more must yet be done before safe and satisfactory conclusions can be reached as to the amount of coal and its position. Up to the last year or two, in no single instance was a survey of the underground workings made or plans kept. The memory of the "old men" was the only source from which information could be obtained as to the extent of the workings, the mode of occurrence of the seams, the disturbances to which they had been subjected, &c. This system, however, or rather want of system, has been changed in some cases, and plans are now kept. On this subject Professor Oldham justly remarks, "Considering the many ways in which danger to public safety (putting aside altogether the serious risks to private property and to individual life) results from abandoned mines and excavations, and from an ignorance of their true limits, I am compelled to think that the keeping and recording of such plans ought to be rendered compulsory. The cost to the colliery proprietors would be slight, while the advantages, even to them, would be inestimable. In hundreds of cases, the safety, nay, the very possibility, of working certain mines, or parts of mines, will depend upon the accuracy of the knowledge of the limits of adjoining excavations, or upon sacrificing much valuable material by leaving unwrought greatly larger barriers than may be necessary. Such plans, ought, I think, to be, therefore, insisted on, under penalties for neglect of this precaution."

Turning now to the fields actually known up to the present date in India, the following list gives the names of the several fields in the order of their successive geographical distribution, commencing with those nearest to Calcutta and proceeding westwards, taking first those which occur in the great band of coal-fields stretching from Calcutta towards Bombay, and then those which are comparatively distant or isolated:

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|---------------------------------|--------------------------------|-------------------------------|
| 1. Rajmahal Hills. | 11. Upper Sone. | 20. Murree, and other places. |
| 2. Raneeunge. | 12. Koorba, or Belaspore. | 21. Darjeeling. |
| 3. Kurhurbali. | 13. Talcheer. | 22. Assam. |
| 4. Jherria. | 14. Nerbudda, and Pench River. | 23. Khasia Hills. |
| 5. Bokaro. | 15. Chanda. | 24. Garrow Hills, Cachar. |
| 6. Ramghur. | 16. Kota. | 25. Cheduba, Sando-way. |
| 7. Karunpoora, North and South. | 17. Cutch. | 26. Burmah. |
| 8. Eetcoora. | 18. Sind. | 27. Tenasserim Provinces. |
| 9. Palamow. | 19. Salt Range. | |
| 10. Sirgoojah: Singwile. | | |

In the Rajmahal hills, coal deposits occur in many places situated in the valleys of the streams which drain across that district. To the south, in the basin of the Brahmini, four or five seams are known, varying in thickness from three to twelve feet; from some of these fair coal has been extracted in former years, but the absence of roads and the distance to which the coal must be carted before reaching any economical means of carriage prevent their being steadily economised. Further north, in the valley of the Bansloi stream, several valuable beds of coal also occur, as well as in the Gosmani valley, and towards the north-western end of the hill-range near Borah; but the same causes as those above referred to have led to the stoppage of all works in these localities.

The Raneeunge coal-field is at a distance of 120 to 160 miles north-west of Calcutta. It extends from a few miles to the east of the village of Raneeunge to several miles west of the Barakur, the greatest length being, near east and west, about 30 miles, and the greatest breadth about 15 miles. The area included by the coal-bearing rocks is about 500 square miles. The field consists simply of a series of beds, divisible into three groups, which have a general dip from the northern boundary to the south, at angles varying from 5° to 20°. Along the southern boundary the beds are turned up, and all cut off by a great fault. There is a total thickness exhibited by the series of rocks of more than 8000 feet; and in this series there is a thickness of workable seams of coal of from 100 to 120 feet. Towards the centre of the field, there rests

unconformably on the coal rocks a series of beds of a more recent geological age, and not containing coal, which cover about one-fifth of the entire area of the field. The coal of this field, like most Indian coals, is a non-caking bituminous coal, composed of distinct laminae of a bright jetty coal, and of a dull more earthy rock. The average amount of ash is some 14 to 15 per cent., varying from 8 to 25 per cent. The Raneeunge field has the advantages of two branches of the East Indian Railway, which traverse its richest portions, and afford great facilities for the removal of coal.

(To be Continued.)

INDIAN RAILWAY CONSTRUCTION.

MR. TREDWELL, one of our very ablest men engaged, ten years ago, on contracts for public works, went out to Bombay to take in hand the works of the Great Indian Peninsula Railway, and—to die there. The havoc which was made by cholera, during the progress of the works up the ghauts, was at times frightful, and the native workmen lost all courage and fled in every direction. The difficulties in the way of executing the heavy works of the great inclines, so well designed by the late Mr. James Berkley, were, in consequence very great, we may say tremendous. It is, we believe, no reproach to English engineering that, as we learn by our telegraphic advices from India, "two large bridges over an unopened portion of the Great Indian Peninsula Railway between Kundwah and Hurdah have given way. A crack has been discovered in the largest viaduct at Thull Ghaut, and three other viaducts over the same ghaut are in such a dangerous state that passengers have to leave the trains and walk across. Seventeen other bridges over unopened portions of the Nagpore Extension of the Great Indian Peninsula Railway have been condemned by the company's engineers."

M'HAFFIE'S MALLEABLE STEEL CASTINGS.

TO THE EDITOR OF ENGINEERING.

SIR,—In the article on malleable castings in your last week's issue, referring to the materials employed while melting in the cupola, you say, "The principal compound of the powder is 'oxide of manganese.'" We think it due to ourselves and to the general readers of your ably conducted and usually accurate journal to say that this *guess* of the writer's is very wide of the truth. Metallurgists who have given the manufacture of steel from pig iron their study will at once see that steel castings, such as we make, could not be produced in the manner described in your article, although, for obvious reasons, we do not enter into particulars regarding our Mr. McHaffie's process in making malleable steel castings.

We are, Sir, yours obediently,
M'HAFFIE, FORSYTH, AND MILLER.

Glasgow Malleable Cast-iron Foundry,
Glasgow, October 2, 1867.

FRENCH RAILWAY TRAFFIC.—French railway traffic in the early part of this year showed a certain depression. The Paris Exhibition has, however, greatly revived and extended the movement on five of the six great systems; and in the thirty-seven weeks ending September 16, this year, the receipts showed an augmentation of 1,263,306*l.* as compared with the corresponding period of 1866.

WAR-STEAMERS ON THE CLYDE.—Messrs. Robert Napier and Co. have just commenced the construction of two iron-plated ships for the British Government; they have also in course of construction one iron-clad ram, with a cupola for carrying two heavy guns, and a monitor for the Dutch Government. A gunboat for the British Government has also been commenced at the yard of Messrs. Randolph, Elder, and Co.

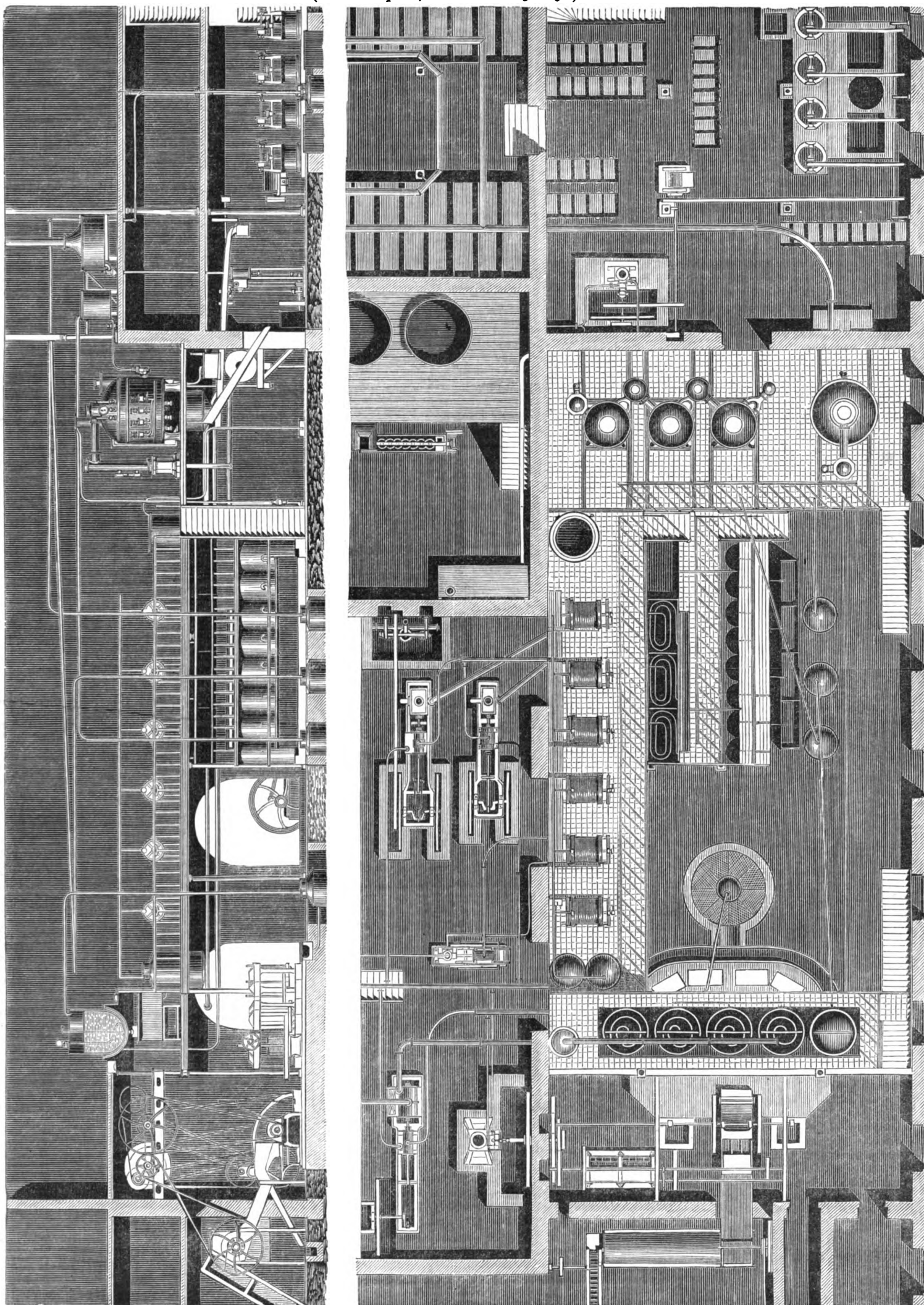
THE PERU.—Messrs. Randolph, Elder, and Co., of Glasgow, have just completed the reconstruction of the engines and boilers of the paddle-steamer Peru, which is now lying in the Glasgow Docks, preparing for her next voyage. This vessel was originally fitted with its engines by Messrs. Randolph and Elder, and the present overhaul did not include any alterations of the plan of the latter, which has been found very satisfactory. The boilers have been renewed, and they now consist of two cylindrical boilers, each fitted with three furnaces at each end, the flues meeting in the middle and returning through the tubes to the two opposite ends of each boiler. The pressure carried by these boilers is 60 lb., and they are placed parallel to each other, and lengthways to the hull of the ship, the longitudinal axis of the two boilers being parallel to the central line of the vessel.

BOMBAY ASSOCIATION OF ENGINEERS.—Bombay has more than double the population of Calcutta, and is now the acknowledged centre of many of the greatest engineering operations in India. It has also large cotton and other manufactories, whose management involves more or less engineering talent. The *Bombay Builder* (now, we may note, under the management of Mr. R. Proctor Sims, resident engineer of the Bombay Reclamation Company) is promoting a Bombay Association of Engineers, and we trust that it will be shortly established. The interest and importance of the late Mr. Berkley's papers upon the inclines of the Great Indian Peninsula Railway, as read by him before the Bombay Mechanics' Institution, help to show the probable future value of such an association, which should be formed and developed as rapidly as possible. Let the Bombay engineers remember the small beginning of the Institution of Civil Engineers forty-nine years ago.

STEAM CULTIVATION.—We find ourselves compelled, at the last moment before going to press with this, the sixteen-page sheet of our paper, to defer the conclusion of our article upon Steam Cultivation until next week. The article is in type, but has been replaced by other matter, already on the press, in our eight-page supplement, while we are now writing.

MACHINERY FOR MANUFACTURING BEET-ROOT SUGAR.

DESIGNED BY M. A. ANDRY, AND CONSTRUCTED BY M. E. DORZEE, ENGINEER, BOSSU, BELGIUM.

(For Description, see the following Page.)

MANUFACTURE OF BEETROOT SUGAR.

We give, on page 329, an engraving showing the general arrangement of the plant of a complete beetroot-sugar factory as designed by M. A. Andry, the engineer of the works of M. F. Dorzé, at Bossu, in Belgium, this set of plant being represented at the Paris Exhibition by a beautifully finished drawing made at the office of M. Annaugand Ainé, in Paris. The production of beetroot sugar in Belgium is a very important manufacture, and a considerable quantity of Belgian sugar is imported into this country every year. The local arrangement and distribution of the necessary plant for beetroot sugar manufacture over a given area of floor, so as to produce the greatest convenience of manipulation, combined with economy of space and first outlay for buildings, is a problem requiring much judgment and experience for its satisfactory solution. We therefore publish M. Andry's design, which we understand has been carried out in several of the most successful establishments of the kind in Belgium and elsewhere; and which is the result of long experience and practice in the construction of beetroot-sugar factories. The details of the sugar machinery employed and constructed by M. Andry do not require any special reference, as they do not materially differ from those of other makers of first-class modern beetroot sugar plant. The manufacture of beetroot sugar is not carried on in any part of the United Kingdom, but it has been recently introduced in the northern states of America, where it is rapidly assuming a very important position. On the European continent, all countries north of 45 deg. latitude are now growing beetroot, and producing sugar from it; the localities where this industry is in its highest state of cultivation being North Germany and Belgium. There is a large production of beetroot sugar in France, and a proportionately still larger make in Austria, a great quantity of beetroot sugar being imported annually from Austria into France. The latter result is due, however, to artificial rather than to natural causes. The sugar in Austria is subject to an excise duty which is levied on the beetroot, and an equivalent of which is repaid as a drawback upon exportation of the sugar. In the practical working of this apparently correct arrangement, the Austrian sugar manufacturers have succeeded in fixing the assumed percentage of sugar in the beetroot at 8.08 per cent., i.e., the Government taxes 1450 lb. of beetroot to the equivalent amount of 100 lb. of sugar. The real average contents of Austrian beetroots, however, is 8.72 per cent., or, in practice, 1108 lb. of beetroot yield 100 lb. of sugar. It is obvious, therefore, that the sugar manufacturer paying the tax on the beetroot, and receiving his "drawback" for the sugar produced from it, makes a profit by exporting the sugar, since he receives a larger sum from the Customs Office than he had paid in shape of taxes on the sugar he exports. The actual difference paid by the Austrian Government in this form amounts to about 1s. 6d. per 100 lb. of sugar, and this explains the fact that there are somewhere about 10,000,000 lb. of beetroot sugar annually sent from Austria to France, the Austrians paying about 7000l. per annum in taxes for the purpose of providing the French with cheap sugar grown on Austrian territory. This is one of those glaring instances of a country impoverishing itself by interference with free trade, which ought to serve as a lesson to many a statesman, a lesson which we regret to see is not yet superfluous nor behind the spirit of the age in the majority of countries on either side of the Atlantic.

WORK BY THE DAY.—We were never more impressed with the dignity of labour than while witnessing, a few days since, a group of "down-trodden working men" engaged in setting up some machinery. There were five of them, or, rather, four men and a boy, and at the time they came under our notice, 5.30 p.m., one was engaged in slowly turning over the contents of a box in search of a screw, two were looking with much interest for the result of the labours of No. 1, the fourth was slowly scratching a piece of iron with a file, and the boy was scratching his head. No. 1 finally found a screw to suit him, but during the search his pipe had gone out. Laying down the screw, he began to investigate his pocket for a match. Nos. 2 and 3 searched theirs in sympathy, while the filer paused to see the result. Finally, No. 2 found a match, ignited it, and handed it to No. 1, who, having accomplished a light, smoked for a few minutes to assure himself of the fact, while the boy went to the other end of the room to look at the clock. No. 1 then looked at his watch, and compared time with No. 3. Time, 5.40. No. 1 then leisurely put the screw into position to fasten a bar. No. 2 held the bar, No. 3 squinted at it from the other side of the machine, No. 4 inspected the whole operation reflectively, as he slowly resumed his filing, and the boy wiped the oil from his fingers. Time, 5.45. The entire labour was now suspended, while the boy went across the room for a necessary tool. Just then it occurred to No. 2 that a chew of tobacco was necessary to his comfort, and, as his supply was out, he applied to No. 3 for the weed, and to No. 4 for a knife to cut it with. No. 1 consulted his watch again. Time, 5.50. And labour was resumed, the screw was turned home, No. 1 tried the bar, Nos. 2 and 3 indulged in a playful scuffle, and the boy looked on with a grin of admiration. The filer laid down his work and looked at the watch, and announced six o'clock. Tools were instantly dropped, and the five, having accomplished the work of two ordinary men, went cheerfully home.—*Boston Bulletin.*

ENGLISH ARTISANS AT PARIS.—Artisans visiting the Paris Exhibition should be cautioned against accepting the invitations of touts for lodgings, who haunt the railway stations and other places, to offer their services to unwary Britons, many of whom have been thus victimised. If a workman, coming to Paris, has not already made in London his arrangements for lodgings, by correspondence with Mr. Hodgson Pratt, vice-president of Mr. Layard's committee, 265, Strand, London, or through Mr. Cook, the well known excursion manager, he should immediately when he arrives in Paris proceed by a cab, which costs two francs, to the workman's lodging-house in Avenue Rapp, close to the Exhibition. If this house be full, then let him go to the British Workman's Hall, in the Exhibition; and ask for M. Houssonnier, and he will escape all fleeing.

MR. PUNCH ON A BROBDINGNAGIAN BARROW.

NEVER did Barrow on a furnace make such a blaze as Barrow-in-Furness the other day when its docks were opened by dukes, lords, honourables, and right honourables, M.P.'s, J.P.'s, mayors, magistrates, magnates, local and municipal—in short by such an assemblage of big and little wigs as it was a triumph to have got together in the dead season.

But the occasion was certainly worth a crowd and a row! A Barrow that has grown, one may say, from a barrow into a coach-and-four in ten years! A Barrow that has swelled almost within the memory of the youngest inhabitant from the quiet coast-nest of some five-score fishermen, into the busy, bustling, blazing, money-making, money-spending, roaring, tearing, swearing, steaming, sweltering seat of twenty thousand iron-workers, and the crime and culture, the dirt and disease, the hard working and hard drinking, the death and life, the money and misery they bring along with them!! A Barrow out of which they are tipping 600,000 tons of iron every year!!! A Barrow big enough to hold a Monster-Iron-Mining-and-Smelting Company, with two dukes among its directors, to say nothing of Lord knows who, in the way of lords, and lord knows how many millionaires!!!!

Talk of the Barrows we read of from time to time as opened with great fuss and excitement in the north by a crowd of archaeologists, headed by the Rev. Canon Greenwell—that most indefatigable of bone-grubbers—with such "finds" as a fractured skull, a ditto brace of urns, a few coal or amber beads, and a "ruckle" of sucked and split marrow-bones!

Here is something like a Barrow, at the opening of which you turn up two live dukes—one of them a senior wrangler into the bargain—and the first of living orators. The occasion was the inauguration of the Barrow Docks. They, with the wharfs, basins, and building-yards about them, cover hundreds of acres. Barrow, we are told, is to be a second Liverpool, Birmingham, Sheffield, Dudley, and Cardiff, all rolled into one. The day that laid the corner stone of such an edifice was surely

"Albo dies numeranda lapillo"

—a day to be commemorated by a Gladstone—and sweetly and sonorously did Mr. Gladstone sing his prophetic Paean; doing his suit and service to King Iron with a grace that might well make King Cotton, his Lancashire liege lord, jealous.

But we have not called attention to this biggest of big Barrows, because of its wonderful growth, its industry, the iron or the gold its miners, smelters, and forgers are making, its Brobdingnagian dividends, or its belching blast furnaces.

The master-spirit of its great iron company is one Schneider. He has hitherto been known to fame among public men chiefly as an ex-M.P., turned out of his seat for Lancaster for gross and shameful bribery. He had seen so much done by energy and money that he probably thought the one as legitimate a lever into Parliament as the other. But he has been punished for his mistake. He has now an opportunity to repair it. His name is the same as that of the President of the French Legislative Assembly, the energetic, far-sighted M. Schneider, whom Mr. Punch has already honoured as the head and heart of the admirably conducted firm which has made the iron-manufacturing district of Le Creusot a model as yet to be imitated among the great English industries of the same kind. What is Le Creusot? It is at once a manufactory and a town—a manufactory that has grown into a town, a town that has gathered about a manufactory, and has of late been described, modestly and in bare figures, by M. Schneider himself, in a report to the Paris Exposition, as well as more summarily delineated in outline by a correspondent of Mr. Punch, on January 12, 1867. He reprints that outline here for the benefit of all whom it may concern, but especially for those who have read the account of the rejoicings at Barrow, and Mr. Gladstone's speech thereon:

"I read your reply to the ladies of Wolverhampton on my return from visiting one of the great iron foundries of France, which, though under one proprietorship, is a small 'black country' of itself. I will tell you what I saw in that great French factory. I saw a town of 25,000 inhabitants, wholly built and owned by the miners and ironworkers themselves, who buy their land in fee simple from their employers as they require it for building. I saw 10,000 of these people, some few of them women, who do light out-door work, go daily to their duties, and 4000 of their children go daily to their schools. I saw drawings and attended historical and scientific examinations in the higher classes of these schools, which would have done credit to Rugby and Eton, and heard, with a longing wish that it were so in England: how none were allowed to leave the school for the workshop till they could read and write well, and do some arithmetic; and I heard with no surprise that several of the higher boys have passed up into the school of Government engineers in France. I saw the château of the proprietors standing in the very midst of this town of workmen, and, within it, assembled round the venerable founder of this great industry, a little society principally composed of the officials of the place, which in refinement and intellect would have done honour to any capital in Europe.

"I saw all this, Sir, but I did not see a policeman or a soldier. I believe there were in the place (of course not near the areas) three of the former, but none of the latter; and finally, during a ten days' stay, I did not see a drunken man, though I once heard one."

And now for Mr. Punch's proposition. Suppose Mr. Schneider were to set himself in real earnest to wipe out the recollection of Lancaster by the redemption of Barrow? What if he were to prove himself the ditto of M. Schneider of Le Creusot, not in name only, but in deed, and to make Barrow-in-Furness the Creusot of England, in morals, manners, civilization, education, domestic comfort and culture, as well as in industry, energy, and money-making? Here is a work worthy of the noblest ambition, the most determined energy, the highest intelligence, and certain of the highest reward—a reward not to be gauged by dividends, it is true, but beyond the measure of millions. Let there be two

Schneiders known in the world for their noble conception and perfect discharge of the duties of a great captain of industry, and let one of them be an Englishman.

And when that second Schneider has done his work, let Mr. Gladstone go down and sing a second and a grander Paean over Barrow—noting its growth, not in trade, wealth, and industry, but in the blessings of a well-taught, well-mannered, well-ordered, cleanly and sober, happy, healthy, hearty population of working men.

INDICATED HORSE POWER.

TO THE EDITOR OF ENGINEERING.

SIR,—It would seem that "J. W. R." has not set fairly before his mind the fact that the area of an indicator diagram is measured solely for the purpose of referring the performance of the strain in the cylinder to the universal standard of "work"—one pound lifted one foot.

If one pound has been lifted one foot, the "work" done is one "unit," whether the time occupied has been one minute or one hour; if one minute, then the "horse power" exerted has been $\frac{1}{33,000}$, whether the lifting force has been constant throughout the time of action or variable. "Work" done is independent of both time and speed; "horse power" is independent of variations of speed.

If the indicating apparatus is correct, and is rightly applied, the area bounded by the diagram lines will represent accurately the "work" done by the steam in the cylinder during that half-revolution; in other words, it will represent

accurately $\int_0^s pds$, where pds is the type of a number of

terms, each of which expresses the pressure at one point of the stroke, multiplied by its own displacement, and s =length of stroke. It only remains, therefore, to measure this area; and this in any given case is a matter of geometry alone, and may be done with a very near approach to accuracy; when measured it may be represented by a rectangle, for every commensurable area may be represented by a rectangle, and every incommensurable area may be represented in the same way, to any required degree of accuracy.

It is true that the methods adopted in practice for measuring diagram areas are often loose and inaccurate. It is unsafe to base calculations upon such measurements; they serve only for rough-and-ready comparisons of one engine with another.

Your obedient Servant,

Crewe Works.

WM. MOORSOM.

THE DUNDERBERG.

TO THE EDITOR OF ENGINEERING.

SIR,—I regret having been unavoidably prevented from noticing at an earlier moment the reply of Mr. John Bourne to my letter on page 26 of the present volume of your Journal.

My exposure of Mr. Ericsson's absurd egotism and Mr. Bourne's unbecoming adulation, manifested in their joint misrepresentation of the Dunderberg on page 546 of the last volume of ENGINEERING, is graciously styled by the latter "minute carplings" at the exposition I have laid before the public of the superior "advantages of the monitor system."

The self-sufficiency of this remark seems to indicate that Mr. Bourne overlooked the fact that my letter charged him with misrepresenting the thickness of armour on a vessel built on a system he is opposed to, and misleading the British public to believe another one, constructed on his favourite plan, has much heavier armour than she really carries, and all this to maintain his argument in favour of the monitors. His persistent suppression of the fact that the armour of the Puritan and Dictator is only 3 in. thick, a few inches below the water-line, and only 2 in. thick below that again, will not be pardoned by those who have been accustomed to accord him their confidence. In his reply, he adroitly avoids correcting his misstatements respecting the Dunderberg, and says I blame him for not stating that the armour of the Dictator, below the water-line, is respectively but two, three, and four inches in thickness, and adds, "it would have been impossible for me to have made the statement, for the simple reason that it is untrue."

To prove the truth of my assertion I send you, with this, a tracing taken from the official drawings of the Puritan's midship section. The armour of each vessel is the same. The armour plates shown on the tracing are 1 in. thick. The scale will show how far below the water line the armour is but 2 in. in thickness. Denying this cheat in the armour, Mr. Bourne, persist in misleading the public in his "exposition of the superior advantages of the monitor system" by re-asserting that the armour of the Dictator is ten and a half inches thick, without letting them into a knowledge of the fact that three narrow longitudinal bars of iron, separated by wooden planking from each other, constitute nearly one-half of the boasted thickness of armour carried by these vessels and those also of the Kalamazoo class.

If you will do me the favour to copy this tracing into your columns, you will enable the public to settle this question of veracity, and at the same time furnish your readers with some unpublished information respecting the ironclad that is designed to carry the first twenty-inch guns on the ocean. (If you fail to publish the drawing, please do me the justice at least to state whether my assertions are proven by it.)

I want Mr. Bourne to understand that I am writing about matters with which I am quite as familiar as he is, though aided by the inventor of the monitors himself; and however impossible it may be for him to make this statement in his reply respecting the armour of these vessels, it would be as well for him, perhaps, to give some other reason for not doing so, than the impossibility of stating what is not true. He has made a false statement to the injury of the Dunderberg, and has failed,

* The "tracing" sent to us by Mr. Watt is really a lithograph, and we have not thought it necessary to reproduce it, as it shows a section almost precisely identical with that of the "Dictator," published on page 290 of the first volume of this journal. There is, however, a difference in the side-armour plating, the thickness of this plating being shown gradually reduced below the water-line, whereas in the Dictator it is shown of the same thickness for its whole depth.

when it was pointed out, frankly to confess it. From this some people may be so uncharitable as to believe the impossibility of his stating what is not true depends upon whether a friend or an opponent will be injured thereby; certainly a difference of ownership of the ox that is gored seems to make impossibilities quite easy with Mr. Bourne sometimes.

I have as little interest in the success or failure of the Dunderberg as any correspondent you possess. I like fair-play, however, and regret to see one whose reputation and ability should be the pride of his countrymen descend to such methods to support his arguments. They might be deemed ingenious and laudable by some in the legal profession, but are certainly unbecoming in an engineer. Deception may obtain an unjust victory, and perhaps secure, through the glorious uncertainty of the law, an impregnable position; but it cannot succeed in a profession that rests solely upon the immutable laws of the Creator, and the practice of which is one constant exercise of veracity.

If there be a seeming want of the proper courtesies of controversy in these reflections, I trust that Mr. Bourne will remember that he has forced me to send the accompanying drawing to defend myself in a question of truthfulness raised by him against me.

Mr. Bourne says, I would doubtless say something severe against the monitors, if I could only find it to say.

One indispensable element in the monitor system, as defined by Mr. Ericsson, is the rotating turret. Without a rotating turret, the vessel could not be a monitor. Against such a system thus defined by its inventor, I have much to say, and would have no hesitation in breaking a lance with the ablest defender of it on either side of the Atlantic.

The rotation of the turret, however, is not the only defect in the system. The hundreds of brave souls that were carried down to a watery grave in the monitors Wehaken and Tecumseh should admonish us that the system of cutting down the sides of a ship to the extent to which it is carried in the monitors may cost more than the advantages gained by it. The less there is of the vessel above water the less certainly will be the amount of armour required to protect her from shot, and the less also will be the quantity of water necessary to send her and her crew to the bottom in case of sudden leakage. The feature which enables them to carry their immense deck load at sea becomes dangerous or fatal the moment the casualties of war, of navigation, of inadvertence, or anything else starts a leak.

I am perhaps more familiar with the various accidents that have happened to the monitors than Mr. Bourne is, and do not know that anything more severe could be said of them than what is contained in the unpublished official reports of the casualties that have befallen them. In our rebellion it was very rare that any shot heavier than 10 in. round solid ones struck them, and these invariably at considerably greater distances than naval battles will probably be fought in the future. A turret that can be jammed with a 10 in. shot will not be likely to resist much heavier ones by simply putting a band 5 by 12 in. around its base. This may defend them against shot of that size, but experience alone will tell how much heavier ones will be harmless against them. The assertion that our 15 in. turrets will resist the 250-pounder navy gun of Great Britain is made in advance of such experiment, and is equally as bombastic as Mr. Ericsson's silly remark to Mr. Bourne that "any of our small monitors could send the Dunderberg to the bottom in a few rounds."

The rotation of the turret gave us, for the time being, an economy of armour in covering the guns, but it brought with it a radical defect in construction, that is, the joint at the deck—one that is inherent in the system. No ingenuity can ever prevent its liability to accident, or make it equally strong with the remainder of the ship.

It would have been almost impossible to have fought the Miantonomoh in ordinary weather at sea during her voyage to Europe, for the simple reason that the working of the vessel rendered it almost a matter of impossibility to rotate the turret. Mr. Ericsson has probably been reticent on this subject to his friend, but the fact is known to every officer of prominence connected at the time with the ship, and can be proven as easily as the thickness of the armour of the Dictator. Mr. Bourne will doubtless say, "If this be so, it is only an evidence that the ship was not strong enough to prevent straining." If it were not necessary to rotate the turret in fighting the ship, she would have sufficient strength for all ordinary purposes. Such a result is an evidence that the slightest causes are sufficient to disable the best monitor yet constructed.

It is a grave question whether the advantage of heavier armour compensate for this objectionable feature, involving, as it does, the necessity of turning a vast quantity of armour every time a gun is trained. The small port and the command of both sides and ends of the ship can be obtained by a fixed casemate, and with a greater economy of iron.

It is within the limits of reason to assert that one-tenth of the Government patronage expended in this country to improve the monitor system would have been sufficient to have developed plans whereby all the advantages of the rotation of the turret could have been enjoyed by vessels with fixed casemates.

A factitious importance has been given to the system by the fortuitous circumstance attending its inception, and this has been increased by newspaper claquers and interested parties to sustain it. This latter course has been pursued to such a degree, by ridiculing and abusing every opponent of the system here in England, that it has obtained a hold upon the uninformed public, apparently establishing its superiority as incontestable.

A passage in Mr. Bourne's reply would lead us to infer that the very able Constructor of the British navy is a convert to the rotating system. I cannot believe it without proof, and I challenge Mr. Bourne to give it. It will not do to say that Mr. Reed is a convert because he is constructing ships with rotating turrets, for this he may do to satisfy the vituperative clamour that has been directed for years past against the Admiralty because of its want of faith in such a system. I desire to see a line that has been said or published in its favour by that gentleman.

Mr. Bourne must abandon his support of the rotating system, or he will become fossilised.

Your obedient Servant,
Washington City, Sept. 16, 1867. WM. WATT, C.E.

CAST-STEEL AND WROUGHT-IRON RAILWAY TYRES.

TO THE EDITOR OF ENGINEERING.

SIR.—It is the special province of journals like the one which you are conducting to disseminate practical truth, and give useful facts and figures, in intelligible language, free from the somewhat pedantic vocabulary of abstract science; and if these journals are frequently denominated "scientific journals," I apprehend that this is due to the assumption that whatever is therein published is concordant with known scientific or practical truth, and conveyed in that precision of language which distinguishes scientific writing from a lawyer's letter, rather than from any purely scientific pursuits in which their editors and collaborators may indulge.

Thus, what renders these journals acceptable to practical readers is the publication of information useful to them in their daily practice, in shape or language free from the mysticism of high science, or from the fog which characterises the school-boy's knowledge of new truths; from the illustrated advertisement, with its list of prizes and of prices, to the more dignified editorial article, with its practical rules and simple useful formulae.

Last week I had occasion, in a letter which you were so good as to publish, to call the editor of *The Engineer's* attention to a paragraph in a practical article lately published in that journal, which to my mind was wanting in anything but precise scientific language, and I beg again to trespass upon your space for a purpose somewhat similar.

In *The Engineer* of September 27, page 267, I found an article on cast-steel and wrought-iron railway tyres, which, as it was not too lengthy, I undertook to read, in the hope of gleaming from it a bit of useful practical truth not as yet known to me; and truth certainly I did find there, since the article gravely informs the reader that "*we may safely say that, excepting Krupp's, of Essen, in Prussia, there is no district so noted for the manufacture of steel tyres as Sheffield.*" But, as I am not a steel-buyer, sent by some extensive business house in the moon, and otherwise knew, ever since I could handle a knife, a file, and a chisel, that Sheffield is the capital of the steel trade, that bit of practical information was of no use whatever to me.

Further on, however, the writer of that article emerges from the strictly practical atmosphere in which he had been moving, to give information of a more scientific kind, and tells the reader that

"*An easy rule for discovering the content of a tyre, when cast and rolled, is found thus: $d = \text{diameter}$, $a = \text{depth of section}$, $d + a + a$.*"

Taking the paragraph as it reads, its meaning is that, by adding to the diameter of the tyre twice the depth of its section, an easy rule will be found for calculating—what?—the content or the contents (?) of the tyre; but clearing away the fog in which the writer's pen evidently was enveloped, I apprehend it means that an easy rule for discovering the contents of a tyre is to add to its diameter twice the depth of its section, thus rendered in algebraic symbols:

$$d + a + a.$$

Now, if the rule be correct, I certainly shall praise its simplicity; but as I always like to go to the fountain-head of all truth, and, in endeavouring to do so, have been unable to reconcile the rule with any known truths in geometrical science, I beg leave, through your journal, to ask the Editor of *The Engineer* to give me a demonstration of it, and until then I shall remain content with the belief that, inasmuch as a sum of lengths must give a length, the tyres, calculated by this rule, will be made up of length only, without either depth or thickness.

I remain, Sir,

Yours very truly,

London, October 2, 1867.

J. J. BIRCKEL.

BUSS'S PATENT FOR PYRAMID-CONCRETE SEA-WALLS, &c.

TO THE EDITOR OF ENGINEERING.

SIR.—In your notice of recent patents, September 20, you kindly refer to my patent (No. 79) as "a system of constructing piers, breakwaters, &c., by building iron caissons of forms similar to that of portions of the proposed structure, and then floating them to their places; after which they are to be sunk and filled in with stones and concrete. It is proposed to build these caissons of the full width and height of the pier or breakwater, &c., and, in some cases, 1000 ft. long; and after they have been sunk they are to be secured by driving piles through their bottoms, and by bolting the adjacent sections to each other. We fear that, unless the caissons were very elaborately and, consequently, expensively stayed, they would never stand the racking strains to which they would be submitted by resting on uneven bearings."

Now it is not intended that these large, water-tight, iron-plate vessels should rest upon uneven bearings. In numerous cases sea and river beds would afford extensive runs of shingle, sand, or mud, so that but little expense would be demanded for preparing the seat. In other instances, asperities could be removed, and hollows filled up with ballast. Thus, when the proposed seat for a vessel already exists, or is rendered suitably even, the advantage of choosing lengths of 500 to 1000 ft. consists in the having of fewer joints in the total length, and also fewer ends to frame and cover with plating. Such even beds would, therefore, avoid the racking strains to which you allude in the above notice.

The object of this invention is to create solid artificial rocks in the form of piers, breakwaters, &c., when possible, where such are required. This is effected by pouring concrete into the water-tight iron shell so soon as it has sunk to its seat. This shell, therefore, need not be thicker or more elaborately stayed than is sufficient to enable it to be floated out of dock and to its destination, to resist the outward pressure of water forcing the iron shell in, to prevent the same being forced out by the expansion of the concrete while solidifying, and to keep out the water (in which it would be assisted by an anti-corrosive paint) until the contained concrete had hardened into a solid rock.

Yours very obediently,

H. BUSS.

THE BIRMINGHAM WIRE GAUGE.

TO THE EDITOR OF ENGINEERING.

SIR.—Mr. Clark has done good service in directing attention to the differences in the value of the Birmingham wire gauge.

I think, however, that it would not be desirable to attempt to introduce a new gauge, for, after all pains had been taken to make it coherent throughout, it would still be a system of arbitrary numbers conveying no idea of actual dimension, and therefore not in accordance with scientific practice. Many manufacturers would not "see the use of it," and there would be great difficulty in securing its universal adoption.

I would propose Mr. Whitworth's system, the decimal gauge, naming the sizes, if you will, according to their diameter in thousandths of an inch; thus, a wire of .010 diameter would be *number ten*, .100 inch *number one hundred*, and so on.

In giving an order for wire, one could specify its diameter with a limit on either side for excess or deficiency; a manufacturer could not object to working to such a specification, although he might defend and object to alter his special number gauge. Thus the matter is very much in our own hands: large users order by decimals, makers will unconsciously fall in with the system.

I would suggest to Mr. Clark that "mil" would very often be mistaken for a contraction of *millim.*, or *millimetre*, and would probably lead to confusion. There is no objection to the word "*thousandths*," it is not very long, and has the merit of being very definite.

Yours truly,

R. S. CULLEY.

The Electric and International Telegraph Company, Engineer's Office, Telegraph-street, E.C., Sept. 30, 1867.

RAISING THE STEAMER DRUID.

TO THE EDITOR OF ENGINEERING.

SIR.—We observe a paragraph in your issue of the 20th ult., relative to the raising of the steamship *Druid*, which is calculated to mislead as to the performance of the pumps employed to empty her, and, as the makers of the centrifugal pumps mentioned, we beg that you will give prominence to a correct statement of the facts, as contained in the following extracts from letters we have received from Messrs. R. W. Consens and Co., of 23, Great St. Helen's, agents for the ship.

"Mr. Roberts's pump gave us every satisfaction, and was quite equal to the work it was put to, viz., pumping out the after-hold. It is also true that it was made available for discharging the grain whilst the air was too foul to admit of men remaining in the hold; but we feel bound to state that your 8 in. pump worked admirably, and rapidly exhausted the water in the fore-hold, notwithstanding the large hole in the bottom of that compartment."

"The after-hold of the *Druid* was the smaller of the two, and quite water-tight; it would have been useless putting a powerful pump, such as the one we had of you, when a much smaller one was all that was necessary. We may repeat that your 8 in. pump gave us more than satisfaction, as also the one we hired for the engine-room, which was also of your make. In both these compartments the pumps had to overcome a rapid flow of water through large holes in the bottom."

We have only to add that the failure in the first instance is to be clearly attributed to the inadequacy of the powerful (?) hand-pumps employed to empty the after-hold.

We trust to your sense of justice to give equal publicity to this statement as you have given to the paragraph to which we refer, and are,

Sir, your obedient Servants,

GWYNNE AND CO.

Essex-street Works, Strand, October 1, 1867.

JENSEN'S HORSE-WHEEL.

TO THE EDITOR OF ENGINEERING.

SIR.—Will you kindly allow me a short explanation respecting this invention, which you illustrated and described last week? It is neither designed nor invented by me, but was patented by me as a communication from abroad.

In the report on the agricultural show of last year at Aarhus (Denmark), page 148, the judges made the following remarks about this horse-wheel, which obtained the first prize: "For each roller passing the worm, the latter turns once, consequently 'in this case thirty-six times faster than the crown-wheel with the rollers on.' Thus a very great speed is obtained at 'once without intermediate gearing, which is a great advantage.' As the construction was entirely novel, it was important to know how great was the percentage of power really transmitted from the horse-wheel to the machine. This was accordingly found by applying a spring balance between the horse and the pole, and a dynamometer on the driving-shaft leading to the machine, and the effective power remaining amounted to 79 per cent., which is a very satisfactory result. The ordinary horse-wheels yield only 60 to 65 per cent. I saw myself, a few weeks ago in Denmark, a patent horse-wheel which had been at work in the open air for the last two years, and it showed no perceptible wear or other deterioration. They are considerably lighter, and work with much less noise or jar, than the ordinary horse-wheels. The three or four horse apparatus drives direct on to the thrashing-machine by pulley and strap, as the driving-shaft from the horse-wheel goes at a speed of 120 revolutions a minute, and can easily be constructed to go quicker if required. The 'intermediate motion' (costing from 4*l.* to 6*l.*) now used to get up the speed is thus dispensed with; but the patent horse-wheels are even cheaper to make than the ordinary ones with 'second motion,' thus causing another saving both to the maker and the user."

I remain, Sir, yours truly,

PETER JENSEN.

Gordon Grove, Holland-road, Brixton,
October 2, 1867.

BRITISH STEAMERS.—The number of registered steam-vessels of the United Kingdom engaged in the home trade was in 1852 858. In 1859 the total had increased to 374; and in 1866 it stood at 612. The number of similarly registered steamers engaged partly in the home and partly in the foreign trade was, in 1852, 42. In 1859 the total had increased to 59, and in 1866 it stood at 110.

ZEUNER'S VALVE DIAGRAM.

TO THE EDITOR OF ENGINEERING.

SIR,—It is likely that many who do not understand trigonometrical formulæ will not examine Zeuner's interesting valve diagram, illustrated in *ENGINEERING* last week, unless their attention is called to the explanation on page 306.

It is much to be desired that simple propositions should be simply demonstrated, so as to be intelligible to the greatest number.

While grateful to the writer for real information, one cannot see the use of much of the algebra. Thus we have

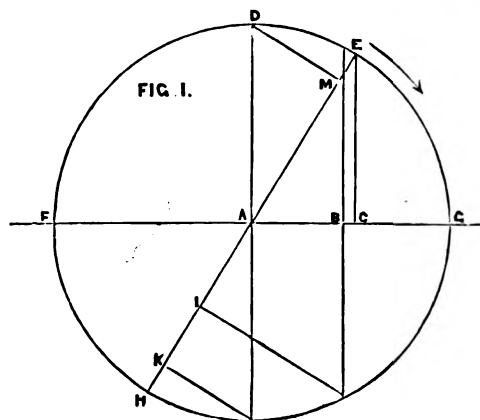
$$O B = r \sin (\omega + \delta) + \sqrt{r^2 - r^2 \cos^2 (\omega + \delta)} + l,$$

and complex equations to prove the self-evident proposition that, if we neglect the disturbances caused by the obliquity of the eccentric rod,

$$\xi = r \sin (\omega + \delta), \text{ i.e., } = C E.$$

Those who have studied polar equations can see through the construction at once: those who have not are unenlightened.

The following diagram may be new to many to whom it would be useful:



Given,

A B=lap on steam side of valve.

B C=lead to steam.

A D=throw of eccentric.

Then angle F A E=angular advance of eccentric.

A C=lead to exhaust.

B G=maximum opening of port to steam.

A G=exhaust.

Imagine E H to represent to scale the stroke of the piston; or divide H E into as many equal parts as there are inches in the stroke of piston, that each division may represent an inch of the stroke.

E I represents that part of stroke made before steam is suppressed.

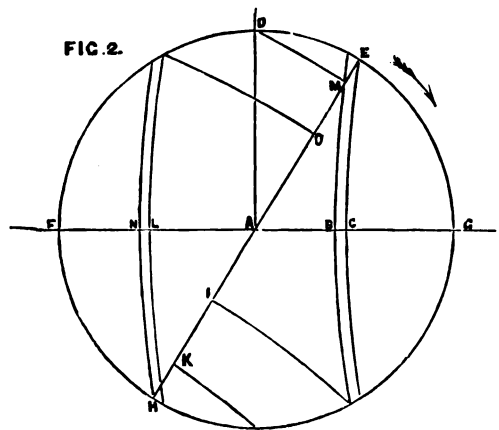
I K represents the expansion.

K H, the premature release.

M E, the compression.

From the obliquity of the connecting-rod the suppression and release are not at the same point on both strokes. The above are mean positions.

But if we require the exact points for each stroke, circular arcs must be drawn with the length of the eccentric rod, and also of the connecting-rod, measured from the scale on H E, for their radii, as shown in Fig. 2.



Here the angle F A E=angular advance of eccentric, is obtained as at first.

A B and A L=lap on steam side at each end.

B C and L N=lead

B G and L F=maximum opening of port to steam.

E I and H O represent that part of stroke made before suppression, on the supposition that E H represent the whole stroke of piston as before.

I K and O M, represent amount of expansion.

K H and M E, premature release.

M E and K H, compression.

Yours truly,

W. H.

Lincoln, Oct. 1, 1867.

SHEFFIELD.—No very great change is reported in the state of trade at Sheffield; but, upon the whole, an improved feeling appears to exist. More activity is shown in armour-plates, and it is stated that one firm has received sufficient orders to keep its men well employed until Christmas. There is a fair demand for railway matériel, a continued preference being shown for steel rail.

BORING LOCOMOTIVE ECCENTRIC STRAPS.

FIG. 1.

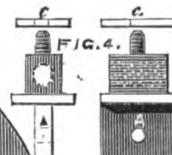
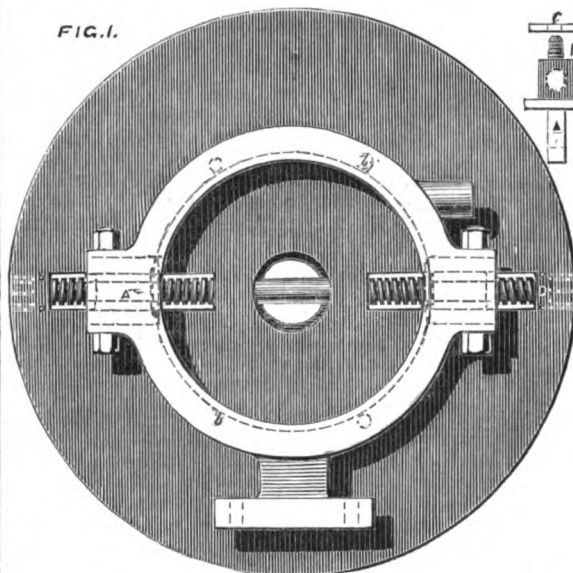
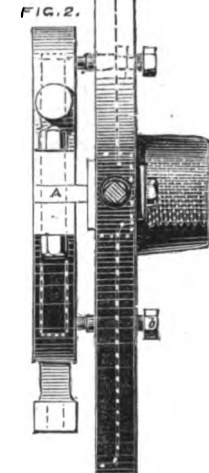


FIG. 3.



FIG. 2.



TO THE EDITOR OF ENGINEERING.

SIR,—Enclosed is a tracing of a lathe chuck which I have designed for the purpose of turning locomotive eccentric straps.

The chuck is very plain and simple, and to a practical eye needs little explanation. Fig. 1 is a front view of chuck; Fig. 2, an edge view; and Figs. 3 and 4 show a gauge and details. The chuck is similar to a common claw chuck. It is provided with two grips or nuts, A, to which the eccentric strap is bolted. It has only one screw, with left and right hand thread to enable the nuts, A, to move together to suit different sizes of eccentric straps. The nuts, A, are fastened at the back of the chuck by a common nut and washer, C, as in ordinary chucks. The chuck screw is prevented from coming out of its place by two loose washers, D D, secured by two taper pins. E E is an iron gauge with two holes bored in it the same size and centres as holes in eccentric straps. This gauge is case-hardened, and is used when boring the bolt holes in eccentric straps to get them all the same. The grips or nuts, A A, are made the same thickness as the liner required for the eccentric straps.

Nuts or grips of different thickness may be made to suit different eccentric straps. The lugs of the eccentric straps are faced up, and then bored to the gauge, and then put on the chuck and fastened with two bolts, the same as putting them in working order.

The bolts, b, which are four in number, are for the purpose of steadying the strap while under the process of turning. The grips, A A, are recessed with the first strap that is turned, so that after the first strap is turned they will, with care, serve as gauges for all the rest (the same size, of course).

Eccentric straps are generally fastened in the ordinary four-claw chuck supplied to most lathes. They have to be drawn in, or lined off, before the turner gets them. Then he has to set each one, and by gripping them in the ordinary claw chuck they are liable to spring when taken out; consequently they are not round. By the use of this chuck the eccentric straps need no drawing in, nor yet setting. The most particular thing is to have the grips, A A, the same thickness as the liner required, and the holes of same size, which can be easily done.

By the use of this chuck, new eccentric straps can be turned much more quickly and cheaply than by the ordinary plan, and they can also be finished more accurately.

If you think this worthy of a corner in your wide-spread paper, you will oblige by inserting it.

I am, yours, &c.,

GEORGE RATCLIFFE.

Highland Railway, Inverness, Sept. 23, 1867.

COAL-CUTTING MACHINES.

TO THE EDITOR OF ENGINEERING.

SIR,—One can understand the anxiety of your correspondent, 'X. Y. Z.' that the value of the coal-hewing machines I described in your impression of the 20th September should not be overrated, seeing that he is patentee of another system.

I, as you justly remarked, have no pecuniary interest in the matter. I merely described what I saw, and I submit that, comparing what I did see with coal-hewing by hand, my anticipations of the results attainable by this machinery are not very extravagant.

If 'X. Y. Z.' has such a much more complete and perfected system (which, however, is more than doubtful), then I should be one of the first to acknowledge its merits.

'X. Y. Z.' however, makes some statements which I cannot pass unnoticed, and I affirm,

1. That hewing or undercutting the coal is the most burdensome part of the collier's work in getting coal, and this work the machines I described perform much more perfectly and economically than hand labour does.

2. That although the long wall is the system best suited to these machines, it is not absolutely necessary; and further, if these machines would tend to the more general adoption of that system, which would save millions of tons of coal to the country, they would confer an additional boon.

3. Three feet headway, or more, is not necessary to the success of these machines; they can be worked in 2 ft. and less.

4. The system of roof pressure is mentioned by me as an ingenious adaptation of means to a certain end, and though it may not be applicable under all circumstances, yet it is only the straight-action machine that requires it. The pick-action one

requires no supports whatever, and is, perhaps, the modification most applicable under ordinary circumstances.

In conclusion, I beg to repeat my belief that until 'X. Y. Z.,' or some one else, brings out a machine that does more or better than the one I described, the latter deserves the most serious attention of the coal-owners.

Middlesboro'-on-Tees.

J. G.

TO THE EDITOR OF ENGINEERING.

SIR,—With regard to my letter on the above subject in last week's *ENGINEERING*, I beg leave to explain that my only motive for withholding my name was, that I was anxious to avoid, as far as possible, making use of your correspondence columns as an advertising medium. This, of course, cannot always be avoided in correspondence, as, for instance, in the case of the Corliss engine. But in the present instance I think you will allow me credit for having done, by avoiding all reference whatever to any of my own plans of cutting coal, and by withholding my name. Persons conversant with colliery matters will be able to take my remarks for what they are worth, and to 'J. G.' and others my letter may, without serving the purpose of an advertisement of my own plans, suggest matter for further inquiry and investigation. You are quite at liberty to append my name to this letter, if you think fit. Meantime I sign myself, as before,

X. Y. Z.

THE EBBW VALE COMPANY.

THE secretary of the Ebbw Vale Company has sent the following letter to the editor of the *Globe*, the same paper, by the way, that lately published the startling prophecy that the Metropolitan Railway was likely to be blown up by fire-damp:

"TO THE EDITOR OF THE GLOBE."

"7, Laurence Pountney-hill, Cannon-street,

"London, Sept. 26, 1867.

"SIR,—I am requested by the chairman of the Ebbw Vale Company (Limited) to contradict the statement contained in the paragraph inserted in your paper of the 24th inst., respecting the management of the works of this company, no change of the kind having taken place, or being under contemplation.

"I beg to remain, Sir, yours respectfully,

"EDWIN GROVE, Secretary."

TUNNELLING AND MINING BY MACHINERY.*

By HERMAN HAUPT, Civil Engineer, U.S.

(Continued from page 312).

To proceed to the consideration of the objections which have been enumerated.

1. The space occupied by the boiler.

Space is limited in a tunnel only in two directions, height and breadth. In considering the subject the ordinary dimensions of a tunnel heading in America will be taken, say, 6 ft. high and 15 ft. wide. No difficulty can exist in conforming to these dimensions elsewhere.

The boiler used in the experiments at the Franklin Tunnel was of locomotive form, 8 ft. wide, 5 ft. high from track, 10 ft. long, and was estimated at 58 horse power.

The power required for nine drills, at 3 horse power each, was 27 horse power, and the boiler was therefore double the capacity that was actually necessary; but an excess of power is no disadvantage.

The gauge of the track being 40 in., the extreme width of boiler outside of wheels was 4 ft., leaving 11 ft. in the width of the tunnel unincumbered.

As the tracks are supposed to be of the usual gauge adopted in the mines of Pennsylvania, 40 in., and as the frames of the stone cars do not project beyond the wheels, the extreme width would be 44 in., and two tracks would occupy, with cars, 7 ft. 4 in., leaving 3 ft. 8 in. clearance to make up the 11 ft.

It appears, therefore, that even opposite the boiler there would be abundance of room for two tracks to carry away material, when in fact only one track at this point would be required. A siding to hold and shift cars would be placed behind the boiler, where the whole width of the tunnel could be made available.

* Paper read before the British Association at Dundee.

The space occupied by the boiler, therefore, causes no inconvenience.

The next objection is the inconvenience of carrying fuel and water into the tunnel.

Water must be used in any system, and the inconvenience in one is not greater than in another; a pipe must be carried into the tunnel and extended from time to time as the work progresses. When the boiler is run back for the purpose of blasting, the tank attached thereto can always be filled without inconvenience or delay.

The stone cars which carry out material always return empty; and even if the quantity of fuel required should be increased fourfold, no expense or inconvenience could result from its transportation.

We will ascertain what amount of fuel can be consumed in twenty-four hours.

Nine drills should finish nine holes in twenty minutes. If twenty-seven holes be blasted at once, and eight blasts be discharged in twenty-four hours, the time actually occupied in drilling will be eight hours. The quantity of water evaporated when nine drills are at work will be 27 cubic feet of water per hour, in eight hours 216 cubic feet, requiring one ton of coal or two cords of wood. Certainly not a very serious item either in cost or transportation.

The next objection to be considered is the difficulty of creating a draft in the boilers without chimney or any of the ordinary means of accomplishing this object.

The provision made for draft consists of a vacuum box or pipe leading from the outside of the tunnel. The proper dimensions of this pipe will be considered under the head of Ventilation, but it is sufficient to state here that a very moderate amount of power applied to a vacuum fan outside of the tunnel will draw the air from the tunnel through the pipe with a velocity so great that if the smoke-pipe of the boiler is connected with it, and the current passed entirely through the firebox and flues, the draft becomes too great, and must be checked by dampers; at the same time all the smoke, gases, &c., are drawn into the vacuum box and carried out, and another anticipated difficulty is thus disposed of.

The next objection is the escape of steam into the tunnel. We ask why should it escape, and where does it escape from?

There is no escape at the boiler except when the pressure becomes so great as to raise the safety-valve; a small pipe on the safety-valve would instantly convey this steam into the vacuum pipe, but if the amount were tenfold greater, it would condense immediately without inconvenience to the workmen.

Steam cannot escape from the pipe, for no loose joints are required, except where the pipe is connected with the bottom of the stand, and as there is but one joint to be attended to, there should be no excuse for any leakage at this point.

The stuffing-boxes of the cylinders and steam-chests present greater difficulties, but these are overcome by a proper mode of packing.

The exhaust steam, it is scarcely necessary to say, does not escape into the tunnel; it is carried by a pipe of 4 in. or 6 in. diameter into the vacuum box, and as the pressure is very slight, this pipe need not be very stout; three-ply gum (india-rubber) hose possesses ample strength.

The exhaust steam escaping in puffs into the vacuum box performs a very important office in greatly assisting the ventilation at the extreme end of the heading, where it is most needed.

Experience in the Franklin Tunnel has proved that a moderate leakage of steam from the pipes or stuffing-boxes is not attended with any inconvenience. In the damp cold atmosphere of a tunnel it condenses quickly, but there is no excuse for leakage; it proves defective workmanship, or careless packing of the stuffing-boxes.

The next objection, of inconvenience from the heat radiated from the boiler is purely imaginary; the very opposite was found to be the fact; the men would get near the boiler when not at work because the warmth was pleasant. If inconvenience were actually experienced, a jacket of felt would prove an effectual remedy.

The damage to the machinery from blasts is no greater with steam than with compressed air, but a barrier is always provided. This barrier, when a tunnel is driven by hand, consists of a pile of stones. Sometimes a barricade of logs is used, sometimes doors faced with logs or boiler-plate iron. A convenient plan of barrier consists in frames 3 or 4 ft. wide, and 7 ft. long, placed in the bottom of the tunnel, where they are not in the way of anything. When a blast is to be made, they are tilted and propped. In blasting in a tunnel, only the smaller stones are projected far enough to strike the barrier, which is not required to be excessively heavy. The frames could be raised by two men, but the operation would be facilitated by the use of a lever.

The difficulty of removing the machinery, very slight under any circumstances, is entirely overcome by the use of the crank. One man can retire the train after drilling, before it would be possible to prepare for a blast.

The last objection is the danger of boiler explosions, but why should this danger be greater in a tunnel than in a workshop or factory? The boiler can be made so strong that an explosion under a pressure of 60 lb. per square inch would be simply impossible, if even the most ordinary intelligence were exercised in its management. A boiler 3 ft. in diameter, composed of boiler plates three-eighths of an inch thick, would be required to sustain a tensile strain of only 1620 lb. per square inch, from a pressure of 60 lb. per square inch in the boiler; this strain is less than one-thirtieth of that which would cause rupture.

Ventilation.

The three indispensable requisites to the successful application of machinery to tunnelling are

1. A machine adapted to drilling holes.
2. A power applicable to driving the machinery.
3. An abundant supply of air.

A failure in either of these essentials would render the others valueless.

There are but two modes of supplying air in tunnelling; one by forcing fresh air into the tunnel through pipes, and driving out the vitiated air at the mouth of the tunnel.

The other mode consists in drawing out the vitiated air through pipes, and allowing the fresh air to enter and replace the vacuum.

These modes of ventilation will be considered with reference to the power required to supply a given amount of air, and the efficiency of the ventilation which is thus secured.

The usual mode of ventilation consists in forcing fresh air into the tunnel through pipes. This is the mode which has been adopted at the Mont Cenis Tunnel, and imitated by the State Commissioners of Massachusetts, at the Hoosac.

The compressed air at the Mont Cenis Tunnel is used for the double purpose of furnishing power for the drills, and by its escape aiding in ventilation.

The power required with the plan of compressors used at Mount Cenis is several hundred horse power.

The ventilation secured in this way is represented by several writers as being exceedingly defective, excepting at the extreme end, where the perforators are at work. A cloudy, smoky, vitiated atmosphere extends from a short distance back of the machinery all the way to the entrance. The men engaged at the enlargement must breathe this poisoned air containing the deleterious gases from the powder-smoke, and the carbonic acid from the lamps and lungs of the miners. In view of these facts, the statement of the press that great mortality sometimes prevails amongst the workmen is not improbable.

By the vacuum plan of ventilation, the powder-smoke and vitiated air are drawn into a pipe, and carried out of the tunnel, while a constant current of pure fresh air flows in at the end, and continues to the face of the work, leaving the atmosphere clear, the lights brilliant, and permitting the instrumental observations of the engineers in giving marks for grade and alignment, without suspending blasting or any other operation.

The power required to furnish a given quantity of fresh air on the vacuum plan was investigated theoretically and experimentally by the writer, at the Franklin Tunnel, in the fall of 1865.

One important result of this investigation was that the power required to draw a given quantity of air through a short pipe was inversely as the square of the area or fourth power of the diameter; in other words, if the diameter should be doubled, the power required would be reduced to one-sixteenth, and therefore in practice the largest possible area should be given to the air-passage.

These theoretical investigations furnished no information in regard to the power expended in overcoming the resistance due to friction in the pipes, and it became necessary to make a practical test to determine data for calculations.

For this purpose, a wooden box was constructed of rough boards. The size of the box or pipe was 110 square inches, inside area; length, 1257 ft.

The pipe was connected with a fan outside the tunnel, driven by a small engine of 10 horse power.

The vacuum fan was 4 ft. in diameter, and the number of revolutions varied in the experiments from 880 to 1220.

The velocity of the air through the pipe was determined by exploding cartridges at regular intervals in the pipe by electricity, and counting the oscillations of a pendulum, regulated to make 100 per minute, from the instant when the key was touched to explode the cartridge, until the smoke appeared at the fan. In this way also the leakage through cracks in the box was ascertained.

The pressure of air in the pipe was determined by an anemometer.

The vane of the anemometer presented a surface of $6\frac{1}{2}$ square inches; it was inserted at any desired point, by making a saw slit in the box; one ounce pressure on the vane represented 1.4835 lb. on a square foot of surface.

A pressure of air of .005 lb. per square foot is due to a velocity of 88 ft. per second.

A pressure of .020 lb. per square foot, to a velocity of 176 ft. per second.

In general, if the velocities are represented by

$$v, 2v, 3v, 4v, n v,$$

The pressure will be

$$p, 4p, 9p, 16p, n^2p,$$

or the pressures are as the squares of the velocities.

The velocity due to a pressure of one ounce on the vane of the anemometer was found to be 1491 ft. per minute, and to obtain the velocity due to any other pressure it was only necessary to multiply the square root of the observed pressure in ounces by the constant number 1491.

Experiments were continued for several days, and the results tabulated; but, although interesting, the practical conclusions are all that will be here stated.

A fan 4 ft. in diameter, and making 880 revolutions per minute, discharged 3674 cubic feet of air per minute, if not connected with pipes.

When attached to a pipe or box of 110 square inches in cross section, the discharge was reduced to 1820 cubic feet, or one-half, when the length of the pipe was 1188 ft., the fan acting to create a vacuum in the pipe, and the air propelled by atmospheric pressure.

Although the experiments were interrupted by the suspension of the work at the Franklin Tunnel, yet it would seem that certain laws may be considered as at least approximately established which govern the motion of air in pipes when produced by creating a partial vacuum at one end, and allowing the atmosphere to act freely at the other.

1. The friction in the pipe being left out of consideration, the power requisite to draw a given quantity of air through a pipe of given length will be inversely as the fourth power of the diameter, or inversely as the square of the area.

2. The quantity of air being constant, the power will be as the square of the velocity.

3. The velocity and power being constant, the quantity will be directly as the area.

4. Power and quantity remaining constant, area must increase according to some function of the distance.

The first three of these laws, which are independent of friction, are modified by those which follow.

5. The velocity, area, and quantity being constant, the frictional resistance will be directly as the length of pipe, and the increment of power required to overcome it will be in the same proportion.

6. The experiments at the Mont Cenis Tunnel establish a sixth law, which is this, the loss of tension or resistance is inversely as the diameter. Now, as the number of particles in

contact with the surface as compared with the whole volume is reduced in proportion as the circumference is increased, this explains the cause of a reduced resistance with an increased frictional surface.

It would follow that, quantity and velocity remaining constant, the resistance should be directly as the perimeter.

Remarks.

The discharge being reduced to one-half, when the vacuum pipe has an area of 110 square inches, and length of 1188 ft. To make the discharge equal to the original quantity, the velocity must be doubled, and the power which is as the square of the velocity quadrupled.

As the quantity is reduced to one-half, at a distance of 1188 ft., three-fourths of the power is required to overcome the resistance of the pipe.

If p represents the power exerted at the fan, $1 =$ distance at which three-fourths of the power is expended in overcoming friction of pipe = 1188 ft.

$A =$ Area of pipe = 110 square inches.

$Q =$ Quantity of air discharged per minute by fan without pipe.

The quantity remaining constant, the power required at the distance 1 will be $4p$, at $21 = 7p$ at $31 = 10p$, at $n1 = (3n+1)p$. But if it is desired that the power shall remain constant, and that the resistances from increased distance shall be compensated by an enlargement of area,

We then have these considerations to lead to the required area (A').

The quantity being supposed constant, an enlarged area reduces velocity in proportion to enlargement.

The reduction of velocity affects power, which is as the square of the velocity.

When the power is increased from p , to $(3n+1)p$, the power being as the square of the velocities, and the velocities inversely as the areas, the power must be inversely as the square of the areas.

$$\text{Therefore } (3n+1)p : p :: \left(\frac{1}{A}\right)^2 : \left(\frac{1}{A'}\right)^2$$

from which it appears that $A' = A\sqrt{3n+1}$.

For example, if $n=5$, then the power required with the area, A , would be $16p$, or sixteen times the power at the fan; but if the area be increased so as to become $A\sqrt{3n+1} = 4A$, the power remains unchanged = p .

To make a practical application of the results which this investigation has developed, let us assume a case applicable to the Mount Cenis Tunnel, in which the air for ventilation is to be carried a distance of four miles.

Let the vacuum box be constructed by flooring over the bottom of a gallery, giving, say, ten square feet of sectional area, and let the question presented be, to determine the power which applied to one or more vacuum fans outside of the tunnel would exhaust 2118 cubic feet of air per minute from the extreme end of the gallery.

It will be remembered that 2118 cubic feet per minute was the estimated quantity required at the Mount Cenis Tunnel, which does not appear from published statements of observers to be actually furnished, although more than 800 horse power are expended in compressing the air.

Four miles equal 21,120 ft., and $\sqrt{3n+1} = 18$ nearly. The power at the end of the tunnel being $p=10$, $n=18$ $(3n+1)p = 550$, or 550 horse power would draw 3674 cubic feet of air per minute through a pipe with an area of 110 square inches, or .76 of a square foot, and of this 540 horse power would be expended in overcoming the friction of the pipe.

If the area is enlarged, the velocity being reduced in proportion to the area, and the power and resistance being as the square of the velocity, they will also be diminished in proportion to the square of the area.

The area being enlarged in proportion as $\sqrt{3n+1}$, or as 1:18, the velocity would be reduced in the same proportion; and if the resistances are as the squares of the velocity, the power to overcome them would be in the same proportion, and would be

$$\text{reduced from 540 horse power to } \frac{540 \times 1}{18^2} = 3\frac{1}{2}.$$

But the quantity of air discharged is to be reduced from 3674 cubic feet per minute to 2120. As the velocities must be reduced in the same proportion, and as the power is as the square of the velocity, the power would be reduced as $3674^2 : 2120^2$, or about 66 per cent. less than the power necessary to pass 3674 cubic feet.

The perimeter of the section in proportion to area must also be considered. An area of 10 square feet in the form of a rectangle ten by one has a perimeter of 22 lineal feet; in the form of a square the perimeter with the same area would be $12\frac{1}{2}$ ft., and in the form of a circle $11\frac{1}{2}$ ft., so that in the rectangular box, according to rule 6, page 52, double the power would be required as compared with a circular area.

After making every allowance, it would appear that with a pipe or box of 10 square feet sectional area, and an application of 10 horse power, more than 6000 cubic feet of air per minute should be furnished, which is three times as much as the hydraulic compressors could deliver with an expenditure of 800 horse power.

Compressed air must move under high tension, at great velocity, and encounter great resistances; the pipes must be very strong, of very small areas comparatively, and very expensive.

The vacuum plan carries the air at a very feeble tension, with very low velocity, with slight resistance, in pipes of rough boards of large area, and furnished at small expense.

To pass 2100 cubic feet of air per minute, through a pipe of 8 in. diameter, requires a velocity of over 1200 ft. per minute, even after compression to one-fifth of its bulk, with corresponding increase in frictional resistance.

The vacuum plan will pass the same quantity of air, without compression, through a passage of 10 square feet at a velocity of only 200 ft. per minute.

It must be observed in the practical consideration of this question of ventilation, that the theoretical results cannot be fully realised, that allowance must be made for the leakage of pipes, for the increased resistances from the rough rocky surfaces over which the air is drawn at the bottom of the tunnel, for the

reduced area of the pipe which is extended for about 150 ft. to the face of the heading, and for the resistances in drawing air through the grate-fines and smoke-pipe of the boiler; but after making ample allowances for all these increased resistances, it must be obvious that the power required to supply a given amount of air is much less on the vacuum plan, with larger air-passages, than on that of compressed air with small ones, and that the ventilation secured is incomparably more perfect. It must be observed also that the number of fans can be increased to any desired extent at trifling cost.

Mountain chains will cease to bar the progress of improvements when the work of a generation in perforating them can be compressed into a brief period, with reduced cost at the same time.

Outlay required for Tunnelling by Steam at Prices of Labour and Material in the United States.

For a tunnel heading 15 ft. wide, 6 ft. high, working nine drills at a time on the face, there should be provided:

27 Perforators (\$ in reserve) \$500	...	\$13,500
8 Stands, \$200	...	600
1 Trussed beam, \$400	...	400
1 Thirty-horse boiler	...	1,500
Car and tender	...	1,000
Dirt-cars	...	500
Engine and fan outside, twenty horse	...	2,500
Machinery for repair-shop	...	5,000
Smith-shop	...	500
Buildings	...	5,000
Boards for air-boxes	...	500
Water and steam pipes, &c.	...	500

\$31,500

At the tunnel of the Alps, the outside expenditures in machinery, buildings, power, &c., are said to have amounted to one million of dollars for both ends.

At the Hoosac Tunnel the expenditures for similar purposes by the State of Massachusetts exceeded \$700,000, chiefly for one end.

The plan under consideration, therefore, compares with others even more favourably in economy than in efficiency.

Mining Tunnel.

To drive a mining-tunnel adit, or level, with a section 6 ft. square, or its equivalent, only two perforators need be used at one time, consuming six horse power of steam. The boiler, if steam be used, may be 2 ft. wide and 4 ft. high. The air-box 4 ft. wide. The trussed beam for handling the drill-stand can be smaller than before described, or the drills can be moved by hand, or on a light iron frame or barrow mounted on wheels. Everything should be on a reduced scale, but the same general principles should be observed, taking care to provide a surplus of power outside, as the difference between an engine that is just sufficient and a larger one is very small.

Estimate for the Equipment of a Mining Tunnel, at Prices paid for Work and Material in the United States.

6 Drills, \$500	...	\$3,000
1 Stand, \$200	...	200
1 Trussed beam	...	250
1 Eight horse power boiler	...	600
Car and tender	...	400
Dirt cars	...	150
Outside engine and fan	...	1,000
Small lathe and other tools for shop	...	1,000
Smith shop, tools, &c.	...	200
Buildings	...	500
Boards	...	200
Water and steam pipes	...	100

\$7,600

Of this equipment it must be observed that very little will be actually used up upon the works; nearly all of it can be carried away when the work is completed, and used again. This is not the case with water power.

Estimate of Cost of applying Machinery to Cornish Mining.

In these mines water is pumped from great depths by means of heavy wooden pump-rods.

These rods afford facilities for making attachments at any level by means of which air-compressors can be worked, and a power generated almost without cost, which is perfectly adapted to operate machinery for drilling the holes required for driving the levels. Even if the power exerted in compressing the air should be four or five times as great as the power exerted by the air when compressed, this will be no disadvantage if the power should otherwise be wasted. A double-acting compressor and a cylindrical boiler-iron receiver, furnished with a safety-valve, would constitute all the apparatus absolutely necessary for compressing air.

The compressor should be of sufficient size to furnish air as rapidly as it can be used by the drilling-engine—say, 30 cubic feet per minute. This amount of air should be furnished by a compressor 15 in. diameter, 9 ft. stroke, making seven strokes per minute. If power is not in excess, it can be utilised more economically by the introduction of more expensive and bulky machinery.

An estimate of cost based on prices furnished by Nicholas Sara, Esq., mining and mechanical engineer, of Cornwall, would be:

For reservoir of 140 cubic feet capacity	...	20
Four drilling-engines, two in use and two in reserve, 40 h. each	...	160
Stand for mounting drills	...	30
Valves, pipes, and couplings	...	15
Cast-iron pipes, 2 in. in diameter, 2s. per fathom, 100 fathoms	...	10
Incidentals	...	20

Total cost ... £255

With two drilling-engines, the progress in drilling, as compared with hand labour, should be ten to one in favour of the machines.

Estimated Progress in driving Railroad Tunnels.

Nine drills are supposed to be set at work in a heading 15 ft. wide by 6 ft. high, and to drill three sets of holes before removal.

Suppose a blast has been made. The barriers are immediately lowered, requiring two minutes, tracks laid in five minutes, first drill-stand picked up and run forward in five minutes. In the mean time the smoke has all been cleared by being drawn into the vacuum box, and a space of 1 square foot at least cleared for the bottom of the first drill-stand. The stand is then set in its place, and the men who attend to it proceed to adjust it, and place the drills in position while the trussed beam is used to pick up and place Nos. 2 and 3 in the same manner.

In fifteen minutes from the time of a blast, stand No. 1 can be at work, even allowing ten minutes to move forward the boiler and make the one connexion which is all that is required to admit steam, and one for the exhaust.

In any ordinary rock, the rate of drilling will not be less than 2 in. per minute; but allow twenty minutes to drill a hole 26 in. deep, and ten minutes to shift the stand after one set of holes has been drilled, the three sets of holes and the intervals will consume one hour and twenty minutes; add the fifteen minutes which elapse before the first set of drills commences work, and fifteen minutes more between the removal of the first and last stands, and the time thus far amounts to one hour and fifty minutes.

There remains the loading and blasting of the holes.

The holes should be loaded as fast as drilled, so that when the last three holes are finished, all the rest are ready for blasting; five minutes should finish the loading, and at the end of ten minutes the electric messenger can be sent to do its work of simultaneous explosion. In the mean time the boiler has been run back, the barrier raised, the debris from former blast removed, and all ready for the next explosion.

With such thorough drill as is exhibited in the exercises of an artillery battery, there seems to be no difficulty in blasting once in two hours, or at least ten times in twenty-four hours; and the progress could not be less than ten lineal feet per day. The average progress in the Hoosac Tunnel was one foot for each twenty holes drilled by hand with separate explosions. Twenty-seven holes fired at once should produce a far greater effect, not considering the advantage to be derived from the use of more powerful explosives than blasting powder, and ten simultaneous blasts per day should give a progress of not less than 12 ft. at each face. If this could be accomplished, it would be a progress six times as rapid as the progress by hand-labour.

Estimate of Cost.

Twenty-seven holes blasted ten times in twenty-four hours, each hole consuming $\frac{1}{4}$ lb. of powder would give:

135 lb. of powder at 20 cts. per lb.	...	\$27.00
1000 ft. of fuse or its equivalent	...	18.00
Steel same as powder	...	27.00
Light	...	4.00
Fuel, 1 ton coal	...	10.00
Two engineers outside \$3	...	6
Six machinists \$3	...	18
Four blacksmiths \$2.50	...	10
Twelve machinists at drills \$3	...	36
Two firemen in tunnel \$2	...	4
Eight to remove material \$1.75	...	14
Four carmen and drivers \$1.75	...	7
Eight extra \$1.75	...	14

Forty-six Total labour ... 110.00

A progress of 12 ft. would cost \$16.33 per lineal foot, or \$5.40 per cubic yard, which is about one-half the cost by hand-labour, with six times the progress per day.

With so large a margin to cover contingencies, it would seem safe to assert that the use of steam in tunnelling will save at least half the time and 25 per cent. of the cost, as compared with hand-labour.

Space occupied by Gases generated in Explosions.

Twenty-seven holes blasted simultaneously, each containing six-tenths of a pound of powder expanding 18 cubic inches of space, expanding 2000 times its original volume, would give, $27 \times 18 \times 2000 = 562$ cubic feet.

1728

$\frac{562}{90} = 6.2$ lineal feet, as the space occupied in the tunnel.

If the exhaustion of air at the extreme end is at the rate of even 1200 cubic feet per minute, the smoke would all be removed in half a minute.

Air required for Tunnelling.

In the use of steam, the air required may be determined by the following data:

Sixteen pounds of air are required for the combustion of one pound of coal.

One cubic foot of water is evaporated by 10 lb. coal, and represents 1 horse power.

One pound of air weighs .075 lb. avoirdupois; 1 horse power consumes 160 lb. of air, or 2133 cubic ft. per hour.

At the Mount Cenis Tunnel it was estimated that 10 cubic metres of air per hour were required for the respiration of one man;

Seven cubic metres per hour to support the combustion of one lamp.

Two hundred and fifty cubic metres of air are required to dilute the gases generated by the explosion of one kilogramme of powder to an extent sufficient to permit them to be taken into the lungs, all of which, it must be observed, is saved by the adoption of the vacuum plan of ventilation, as this pernicious air is not breathed by the workmen.

The quantity of air required will be determined at the period of maximum consumption when the greatest number of men are in the tunnel and the machines all at work.

Nine machines consuming each 8 horse power of steam require a 30 horse power boiler, consuming 300 lb. of coal per hour, and 64,000 cubic feet of air per hour, or 1066 cubic feet per minute.

Twenty-three men in tunnel, each 353 cubic feet per hour, or 6 cubic feet per minute	138
Twelve lamps, each 247 cubic feet per hour, or 4.6 per minute	55

Air required per minute ... 1259 cubic feet.

To furnish this amount of air by a vacuum fan at a distance of two miles through a pipe or box of 10 square feet sectional area would not require 5 horse power.

Improved Means of Furnishing Light.

The attention of the writer has not been confined to the consideration of the primary essentials in tunnelling. He has experimented to some extent on other means of facilitating progress by securing improved means of lighting and blasting, some of which will be briefly alluded to.

To dispense with the smoke of lamps or candles, and secure a brilliant light, a large magneto-electrical machine was constructed under the direction of Mr. George W. Beardslee. This machine was no doubt the largest of the kind ever constructed; its weight was 3 tons, and cost over \$3000. It was intended to drive it by means of the engine outside the tunnel, and convey the current by wires, the light being produced by a coil of platinum wire in the focus of a parabolic mirror. Although a brilliant light was obtained by means of this machine when the reflector was within 100 ft., yet it was found impossible to carry the current to any great distance from the machine, and therefore it was not used in the tunnel. The present plan of operations in which the boiler is movable would permit such a machine, or any other that might be found preferable, to be attached to the rear end of the tender, and rotated by a small steam cylinder. This would obviate the necessity of carrying the current any considerable distance from the generating machine.

Improvements have recently been made in the production of electrical light, and there is but little doubt that it can be made practically available in tunnelling and mining.

Alignment.

The same apparatus which produced the light was intended to be used in maintaining the grade and alignment, by projecting on the face of the rock from the reflector the shadow of a cross from which both the vertical and horizontal measurements could be made a mark, always before the eyes of the workmen, and which blasts could not efface.

Blasting.

Another use to be made of the electrical apparatus was in securing simultaneous discharges from a large number of holes. Experiments were made with a smaller machine, constructed by Mr. Beardslee. It was found that a cartridge could be exploded at a distance of 100 miles, using the ordinary telegraph wires. Also, that fifty cartridges attached to a wire outside the tunnel would all explode, but inside the tunnel not more than six or seven of the holes would be exploded. The cause of this was ascertained, and experiments were in progress to provide a remedy when the suspension of operations at the Franklin Tunnel put a stop to them, and no opportunity of renewing them has since been presented.

The last report of the State Commissioners on the Hoosac Tunnel shows that efforts in the same direction have been made by them, that their engineers, assisted by Colonel Schaffner, could not explode more than about five charges at once, but that certain suggestions were made, in consequence of which new machines and fuses were procured, by the use of which so many as thirty-one charges have been fired at once.

If this machine is not exactly what it should be, no doubt can be entertained that the difficulties will be overcome, so soon as the attention of electricians shall be more generally directed to the subject. In fact, it would appear that the Abel fuses exploded by the ebonite battery leave little to be desired.

Loading Holes.

The old way of pouring in loose powder and tamping with stones will not answer in expeditious tunnelling. The only proper mode of loading holes is to have the powder enclosed in previously prepared cartridges, in which the fuses or electrical wires are inserted. These cartridges were prepared in the following manner: A stiff case was made by pasting brown paper, and rolling it around a stick, so as to give a diameter of $1\frac{1}{2}$ in.; a paper wad, dipped in paste, forms the bottom; when dry, the powder was introduced, with the fuse or wires, then a wad, then dry sand, until the whole length was about 20 in. In loading, a cartridge was pushed into a hole, followed by a pointed wooden plug tightly driven. The point of the plug would break the cartridge and spread the sand. Lastly, an ordinary railroad spike was driven into the end of the plug, which split it into four quarters, driving the pieces firmly against the sides of the hole. This mode of tamping was found to answer perfectly, and was so expeditious that several holes could be loaded in a minute.

Nitro-glycerine.

The report of the Hoosac Tunnel Commissioners states that the experiments with nitro-glycerine have been very successful; that no accident has resulted from it; that there seems to be little risk if the article is good, and ordinary care taken in its use, and that double progress can be made with glycerine over that made with powder, at less cost. The report states that "whenever its extensive use shall be concluded upon, it will be necessary to secure the services of some scientific person expert in handling it, that some antidote against headache may be discovered, and that the use may be reduced to the lowest possible point."

The antidote against headache caused by breathing the noxious gases resulting from the explosion of glycerine is obvious. It consists simply in adopting the vacuum plan of ventilation, which would carry off any vapours or gases without injury to the workmen, even if they were as poisonous as the fumes of prussic acid.

RAILWAYS IN RUSSIA.—Great activity continues to be displayed in connexion with the development of railways in Russia. Three important sections have been opened of late, viz., from Odessa to Tiraspol, from Warsaw to Tiraspol, and from Balta to Olriopol. Propositions have been renewed for the purchase of the Nicholas line (Moscow and St. Petersburg). The concession has been granted of a line from Poti to Tiflis, while surveys have been commenced for another line from Rostow on the Don to the Black Sea. A line is to be constructed at the expense of the State from Koursk to Karkhow and the Sea of Azoff.

THE PRICE OF STEEL RAILS.

At the present time, and when the utmost working economy, as derivable from the introduction of steel rail, is so important to our railway companies, their purchase is sometimes proposed to be deferred until the expiration of Mr. Bessemer's principal patent, two years hence, in the belief that, because the royalty will then be lessened (for, as several important patents of Mr. Bessemer's will remain still in force, it will not be wholly taken off), steel rails will then be cheaper. Even were the price to be then lessened by the amount of the royalty, which is hardly 7 per cent. of the total price, this policy of delay would be a mistaken one for the true interests of railway companies. Every railway engineer who has had experience of the working of steel-laid lines is now aware that, quite apart from their greater durability, steel rails begin to save in working expenses from the day they are put down, because of the smoother and firmer road which they make as compared with iron, and consequently the lessened resistance to traction and lessened wear and tear. In this respect alone, steel rails are now well known to have an advantage over iron, more than sufficient to compensate for the increased interest, whether simple or compound, upon their greater first cost. The company which, having rails to renew, now replaces them with iron, commits itself to the higher rate of working expenses, not merely for two years, or till the expiration of Mr. Bessemer's patents, but until the rails themselves are worn out, and this may be five, ten, or twenty years, according to the amount of traffic. No policy is worse than to tie down a railway company to the use of an inferior material, and that for a period of years.

But it may be predicted, with almost as much certainty as anything can be predicted of the future, that even when Mr. Bessemer's patents expire, steel rails are likely rather to increase than to diminish in price. In the first place, the present is a period of exceptionally low prices, owing to the general depression of trade, and with any fresh and considerable demand prices will most certainly advance. In the second place, we have already had the full effect of competition, and steel rails have been made and sold less with a view to present profit than to future orders based upon their ascertained superiority over iron. The managers of certain of our largest steel-rail works have assured us that, even where they had tendered to supply Bessemer rails as low as 12*l.* per ton, they had more than once found themselves underbid. When Sir (then Mr.) John Brown was the sole maker of Bessemer rails, his price was 17*l.* or 18*l.* per ton; but now, in the face of sharp competition, this has been brought down by one-third. The great firms of the Barrow Hematite Steel Company, Sir John Brown and Co., Charles Cammell and Co., the Dowlais Iron Company, the Ebbw Vale Iron Company, the Mersey Steel and Iron Company, and the Bolton Iron and Steel Company, in addition to the establishments of the Old Park Iron-works (Wednesbury), the Manchester Railway Plant Company, the Lancashire Steel Company (now, however, in liquidation), Samuel Fox and Co., Henry Bessemer and Co., John M. Rowan and Co., besides the steel works of the London and North-Western Railway Company, at Crewe, are now making Bessemer steel, mostly for rails; and between these firms and companies there has been a keen competition to establish, if possible, an exclusive name and reputation, even at the expense of temporary profits. It is impossible to foretell the results of further improvements, and these are quite as likely to lessen the price of iron as of steel; but the general tendency is towards a rise in prices, inasmuch as labour is rising in price, and, on the full recovery of trade, will inevitably be dearer than now. Hematite iron, spiegeleisen and coke, the raw materials of Bessemer steel, are steadily rising in price; and nothing is more probable than that their increased price, even two years hence, will more than exceed the whole of the present royalty on steel rails. Another circumstance which must contribute towards increasing the price of steel rails is the increasing conviction of their immense superiority—a conviction that railway companies have been much too slow in adopting them generally; and as the result of this conviction alone, we shall yet trace a largely increased demand, which for a time will necessarily advance present prices, now that ironmasters are glad of anything that will keep them at work, and just cover the total cost of production.

It is incumbent upon all business men to look as far as possible into the future, to interpret the signs of the times, and to make their plans with reference to the best-assured prospects of trade. In this spirit of forecast, no railway manager can doubt that, with the Bessemer steel trade (like almost all other trades), now

depressed by the general absence of enterprise, already suffering from competition under a demand far short of the available means of supply, the prices of its raw materials still rising, the probability of an active resumption of general trade at the end of the next two years, if not sooner, and with a rapidly spreading conviction that steel rails are greatly superior to iron, and that they are absolutely indispensable for very heavy traffic, their market price, irrespective of the royalty, must increase by more than the royalty itself. And even were this not nearly certain, the policy of committing any railway company to the use of an unquestionably inferior material for five, ten, or twenty years, according to the amount of traffic, would be a mistaken one in every point of view.

THE CINCINNATI BRIDGE.

WE give this week drawings of the suspension bridge over the Ohio River, at Cincinnati, U.S., a bridge of the widest span yet constructed (1057 ft.), and which is undeniably the finest of its kind ever constructed. We gave some few weeks back a copy of the engineer's report upon the construction of the bridge, from which we repeat a few general dimensions and quantities. We also give a portrait of the engineer, Mr. John A. Roebling, who was also the engineer of the great railway suspension bridge over the Niagara River. Mr. Roebling, a Prussian by birth, has been long resident in the States, and has executed many fine examples, besides those we have named, of wire suspension bridges and aqueducts. He is about to commence the construction of the great bridge of 1600 ft. span over the East River at New York, a bridge which, with its land spans, will be about a mile in length, and which is estimated to cost about 1,200,000*l.*

Main span from centre to centre of towers	1057 ft.
Side spans from abutment to centre of tower	281 "
Total length between abutments	1619 "
Elevation of floor above low water at tower	91 "
" " of Front-street, Cincinnati approach	108 "
" " of Second " Covington "	60 "
Ascent of Cincinnati approach in 100 ft.	71 "
Length of Cincinnati approach from Front-street to abutment	5 "
Length of Covington approach from Second-street to abutment	341 "
Total length, including approaches	292 "
Number of cables	2252 "
Diameter of each	2 "
No. 9 wires in each cable	124 in.
" " both cables	5200 "
Average strength of one wire	10,400 "
Ultimate strength of one cable	1620 lb.
" " of both cables	4212 tons.
Number of stays in main span	8424 "
Strength of each	76 "
Aggregate strength of stays	90 tons.
Ultimate strength of cables and stays	6840 "
Weight of main span between towers	15,264 "
" " as far as supported by cables	1500 "
Deflection of cables in main span	1300 "
Permanent tension to strength	89 ft.
Ordinary working tension to strength	1-8 "
Maximum tension to strength	1-7 "
Section of each anchor chain in square inches	1-6 "
" " two	190 "
Ultimate strength of "two chains	380 "
Elevation of anchor-plates above low water	9500 tons.
Greatest weight resting upon the foundation of each tower	25 ft.
Area of each foundation	82,000 sq. ft.
Pressure upon each superficial foot	8250 s.f.
Cubic content of masonry of each tower	3.88 tons.
	400,000 ft.

AUSTRALIAN COAL.—New South Wales coal can be conveyed to Hong Kong for 1*l.* 5*s.* per ton, while the transport of English coal to the same point involves an outlay of 2*l.* To Calcutta the cost of conveyance in the case of New South Wales coal is 1*l.* 1*s.* 6*d.*, and in the case of English coal, 2*l.* per ton. In the face of such facts as these, one would think that the extraction of coal in New South Wales must steadily increase.

ERRATA.—In the last line of the note to the article, entitled "Mallet *Mirum in Modum*," in our last number (page 322), a misprint occurs. Instead of "say about 170 ft. in diameter" read "say about 1370 ft. in diameter." In the fourth line above this also, for "increases only as the cube of the diameter," read "increases only as the cube root of the diameter."

STEEL FOR SHIPBUILDING.—The application of steel in the construction of ships is making steady progress in the shipbuilding-yards on the Clyde. In the two frigates now in hand for the British Government at Messrs. Robert Napier and Son's, steel enters largely in the construction of the hulls. All parts which require no heating and bending after their being once finished by the steel makers are specified to be made of steel, and some excellent specimens of Bessemer steel-plates and angles made by Messrs. Cammell and Co., of Sheffield, are now under test at the above named shipbuilding-yard. Messrs. W. and A. Inglis are designing a steel ship for the river Plate. It is to be a fast running passenger steamer of 1600 tons measurement, 250 ft. long, and to draw about 7 ft. of water only. It is to be fitted with twin screws, and circular steel boilers carrying 25 lb. of steam. The steel-plates will be punched and rivetted with steel rivets by hand in the usual way.

THE INSTITUTION.—We may state that the question of the right of the Institution of Civil Engineers to expel from its body the gentleman whose conduct formed the subject of the late inquiry, has been submitted to eminent counsel, and that an opinion has been given that the Institution has no legal power thus to expel a member.

THE GREAT INDIAN PENINSULA RAILWAY BRIDGES.

No sooner have we recovered a little from the effects of the startling news relative to the total collapse of the viaduct across the Mhow-ke-Mullee Khind, on the Bhore Ghaut incline, than we learn, from the accounts of the following mail, that two large bridges have been washed away on the unopened portion of the Great Indian Peninsula Railway line between Khundwah and Hurdah, the consequences of which must be to delay indefinitely the opening of that section. A crack has been discovered in the largest viaduct on the Thull Ghaut, the dimensions of which erection is about 200 ft. high and 750 ft. long; and three other viaducts on the same ghaut have been found to be in such a dangerous state, that passengers have to leave the trains and walk across. Seventeen bridges on the unopened portion of the Nagpore extension of the Great Indian Peninsula line have also been condemned by the company's engineers. At present we have not received copies of the reports on the state of all these bridges, but if what we have received concerning the fallen viaduct on the Bhore Ghaut may in any way be taken as a fair representation of the other bridges on this line, we may with tolerable certainty predict a rapid decrease in the interest returns of this line for some time to come, in consequence of the large amounts that must be forthcoming for the purposes of reconstruction.

As the Syhadree Mountains, or Western Ghats, run parallel to the line of sea-coast, they cut off Bombay and other parts from the interior of the country. Across these mountains goes the south-eastern line of the Great Indian Peninsula Railway by means of a series of the most magnificent railway works in the world, consisting of tunnels, viaducts, and gradients, some of which are as steep as 1 in 37. This Bhore Ghaut incline is 15 miles and 68 chains in length; the level of its base is 196 ft. above high-water mark in Bombay, and of its summit, 2027 ft., so that the total elevation surmounted by the incline is 1831 ft., at an average gradient of 1 in 48. The works consist of twenty-six tunnels (the total length of which is 3985 yards) and of eight gigantic viaducts, besides numerous extensive cuttings. The viaduct, which has just collapsed, sacrificing the labour of two years, and 50,000*l.*, is that which crossed the Mhow-ke-Mullee Khind, between Wonee and Thakoorwada, and was the most important on the ghaut, connecting, as it did, the upper and lower ranges of hills. It was also the most extensive on the line, consisting of eight semi-circular arches of 50 ft. span, and 139 ft. above the surface of the ground. So far as the actual works were concerned, however, this does not show their real height, because it was necessary to excavate to a depth of 24 ft. before a sufficiently solid foundation could be obtained. The viaduct was thus 163 ft. high above the footing, and it was built on a considerable curve. It had been known to be at least superficially unsound for several years, cracks having been visible in two of the piers.

The cause of the fall of the viaduct is undoubtedly to be found in its very faulty construction. Sound and substantial as the masonry may have seemed outside, any attempt at inspection when the work was proceeding must have shown the merest tyro in building that the inside masonry was disgracefully insufficient. The piers of this viaduct were built with their casing of cut stone averaging 2 ft. on the bed, whilst the whole of the intermediate portion was of common rubble. The lower part of the pier, forming the plinth, is 2 ft. wider than the shaft, which is carried inwards by two 6 in. offsets. It will be easily understood that a block facing of, say, 24 in. actually makes the face-work of the shaft to stand on only 12 in. of the corresponding work of the plinth, and thus the greater part of the weight is thrown upon the rubble hearting. The piers of all the viaducts on the Great Indian Peninsula Railway are, we believe, built in a similar manner.

In addition to the defects of construction, the lime and mortar used by the contractors must have been very inferior, probably owing to the terrible scarcity of water at the time. So scanty was the supply, that there was not even sufficient for the wants of 24,000 or 25,000 men employed on the works, and who were decimated by cholera in consequence. The mortar and the stones being too dry, no care in building could bind the courses of masonry together, and hence the cracks and downfall of the whole.

The following resolution on the subject, dated 20th July, 1867, has been issued by the local Government: Resolution.—The fall of the great viaduct on the Bhore Ghaut incline has fortunately been attended

with no loss of life, or injury to any person; but it might have been followed with the most deplorable results.

2. The work appears to have subsided under no immediately exciting cause; it was neither subject to the rush of flood-water, nor was it shaken down by a passing train; and there is too much reason to fear that, after an existence of five years, it yielded from defects inherent in its construction, and from causes which have been in operation from the moment of its completion.

3. The embankment of the Sooki Nullah gave way from a similar cause—original defective construction; though in this case there was an active cause in operation which produced the catastrophe, and combined to bring it about.

4. These facts suggest matters for very grave consideration, and call for the most prompt and vigorous action on the part of the railway company's officers, and on that of Government.

5. There is no possibility of determining to what extent faulty and insecure construction may have been carried on; on other parts of this line; and though Government trusts that it may not exist in the case of any other works than those in which it is at present known to exist, his Excellency in Council feels it incumbent on him to do all in his power to set the question as far as possible at rest.

6. In Government Resolution, No. 1475, of the 17th instant, it was remarked that no rule regarding working the line would be of any avail to ensure safety, if bad design or faulty construction be allowed to remain uncorrected; and the attention of the consulting engineer was called at once to the necessity of remedying defects wherever they were known to exist.

7. The correctness of this view has been confirmed in the instance now under notice. The line inspector had passed over the viaduct very shortly before it collapsed, and found nothing to indicate the probability of such a calamity. It is evident, therefore, that all ordinary precautions may, in a case of this nature, prove unavailing.

8. It may be extremely difficult to devise measures which shall be entirely effective in the case of works unsound within, but which present the external appearance of sufficient stability; but nothing that is practicable in the way of testing and examination should be omitted. His Excellency in Council is therefore pleased to direct that the consulting engineer should call upon the railway company to submit reports of every work of construction on the line, and that in cases of bridges the responsible engineer should submit certificates that all masonry in piers and abutments is plumb and without external cracks, that arches are not crumpled or out of shape, and that there has been no dangerous scouring action through waterways.

9. In case any works should be found defective in any of the particulars enumerated, the responsible engineer must make a special report, specifying the exact defects that are apparent, their nature and extent.

10. The engineer should also specify whether the sides and toes of embankments exposed to flood action are pitched or otherwise protected, or not.

11. On the receipt of these reports, the consulting engineer or his deputies should personally visit and inspect the principal works, especially those reported as defective, and, in consultation with the company's engineers, should suggest the measures that may seem most applicable in each particular case to secure the work and prevent accident.

12. His Excellency in Council confidently relies on the cordial co-operation of the railway company's agent and his officers in carrying out promptly and without delay these precautionary measures, which are, in his Excellency's opinion, necessary alike for the safety of the public and the interests and credit of the railway company.

M. K. KENNEDY, Colonel, R.E.,
Secretary to Government.

We believe we are correct in stating, that this viaduct will be replaced by an iron girder bridge, and, in the mean while, a tramway is being constructed for the temporary accommodation of the traffic.

THE PARKHEAD FORGE, GLASGOW.

MARINE engineers and iron shipbuilders on the Clyde, whose demand for heavy forgings, plates, and rolled iron of all kinds is very extensive and important, rely for their supply almost entirely upon a limited number of forges situated in their own district, and laid out on a very large scale. The largest and most celebrated forge in the locality is the Parkhead forge, founded by the late Mr. Rigby, and now carried on, as the firm Rigby and Beardmore, by Mr. Beardmore.

The Parkhead forge is laid out for the manufacture of the heaviest forgings at present in demand. The heaviest article yet produced under the hammers of this establishment is the double crank-shaft of the iron-clad Monarch, a forging which weighed 32 tons in the rough. The weight does not equal that of the great wrought-iron shaft sent to the Paris Exhibition by Messrs. Marrell frères, of Rive-de-Gier, in France, and which is said to weigh very nearly 30 tons in the finished state, and has three double cranks; but it comes sufficiently near in size to this latter to show that the Parkhead forge is fully equal in power of production to the largest forge in France. This refers exclusively to iron forgings, which, as compared with steel, require a smaller weight of hammers. The largest hammer at the Parkhead forge is 7 tons in weight, but the clear span between its standards is fully 15 ft., so as to afford plenty of room for the heavy forgings which are operated upon. The appearance of the steam-hammers in a forge of this kind generally gives the idea of their heads being heavier than they really are, on account of this difference of proportion between the size of the framing and standards and the weight of the hammer-head itself. The cranes, which are placed at the sides of the large hammers at the Parkhead forge, are of the heaviest class, their framings are of timber, and they are worked by steam, each crane having a pair of separate engines for working it. These engines, which used originally to be worked and reversed by a link motion, are now reversed by means of a valve answering the description of a four-way cock, which, by being placed in two alternate positions, effects the reversing of the two engines with great speed, and which is less subject to wear and tear than the link motion. The action of this valve is simply to reverse the position of the steam inlet and exhaust passage; its action is not perfect as regards the economical distribution of steam, but its simplicity makes it preferable in cases like that of the small engines of a forge-crane. There are fourteen steam-hammers, varying from 7 tons downwards. The larger sizes are Nasmyth's patent single-acting hammers; the smaller sizes are made on Mr. Rigby's patent, a type of steam-hammers which is in very general favour in Scotland. Rigby's hammers are made with a solid hammer-head of wrought iron or steel forming the piston, piston-rod, and the hammer-head all in one piece. All guides to the hammer-head are dispensed with by relying upon the stuffing-box, through which the piston-rod passes at the bottom of the cylinder, and upon the piston itself to give a straight movement to the hammer. The possibility of the hammer turning round the axis of the piston-rod is prevented in Rigby's original hammers by planing the stout cylindrical rod down to a flat surface on one side or on two opposite sides. This plan, although effective in keeping the hammer steady in its position, is objectionable on account of the difficulty of keeping a stuffing-box of such an irregular shape steam-tight all round. In some Rigby hammers more recently constructed, the sharp corners have been avoided, the section of the rod approaching more nearly to an elliptical form; but the result was not much better than with the original shape. The most modern design, and one which meets all the difficulties with perfect success, is to make the piston-rod perfectly cylindrical, and to place it slightly eccentric to the piston itself. This arrangement completely prevents any possibility of a change of position of the piston-rod or the hammer-head, and it still maintains the circular stuffing-box with its facility of working and packing.

The smaller Rigby hammers have single cast-iron standards; the hammers exceeding 2 tons have double standards cast in pieces and bolted together. The cranes, which are placed in pairs at the alternate sides of the large hammers, are long enough for the sweeps of the jibs to intersect each other, so as to allow of an easy transport of a heavy forging from one hammer or furnace to another. The anvils used for some purposes, particularly those employed for shingling scrap iron or puddled blooms, are cooled by water circulating through the anvil. This is effected by casting a pipe of about 1 in. in diameter in the body of the anvil at a depth of about 4 in. below the surface of the face. This pipe, which is simply cored out in the body of the cast iron, follows a zigzag course all over the horizontal section of the anvil, returning to the same side at which its course commenced, so that both ends of the pipe are in front, where the water-pipes may then be attached in the usual way. These anvils last much longer and stand a greater amount of wear than solid anvils, and they do not seem to have any excessive cooling effect upon the heated mass placed upon them. The raw materials employed at this forge are both

scrap iron and pig iron of different brands, and they are selected according to the quality of articles to be produced. There are about forty puddling-furnaces, each with a separate single flue, surrounded by a vertical boiler. The pig iron for puddling is a mixture of Scotch, Cleveland, Welsh, and hematite irons, all dark grey; they are charged into the puddling-furnace in 24 cwt. charges, and each charge produces about 1 ton of puddle bars on an average. Six charges are made per furnace in a day of ten working hours, and the consumption of fuel on the grate is about 15 cwt. of best large coal per ton of puddle-bars produced.

The quantity of steam produced by the waste heat is just sufficient to work the hammers and rolling-mill engines; but there is still a considerable amount of heat lost on account of the comparatively small heating surface of the single-flue boilers. The puddled blooms are shingled under a 2½ ton hammer, and then passed through a pair of 24 in. rolls provided with collars and grooves, so as to gauge the mill-bars to an equal and uniform width. The mill is driven at 126 revolutions per minute by a pair of horizontal high-pressure engines, which at the same time work two other rolling-mills. The engines have cylinders 30 in. in diameter, and 5 ft. stroke, and they work with 45 lb. steam pressure at 42 revolutions per minute. The breaking-down mill is geared to the fly-wheel shaft at the ratio of 1 to 3. The mill-bars are used for making scrap for piling and forging, or they are piled and rolled for the production of plates. For the best qualities of plates the mill-bars would be piled and rolled a second time, and then re-heated and finished in the plate mill, each successive heat requiring from 10 cwt. to 15 cwt. of coal to the ton of iron, and wasting about 5 per cent. of the material. For forgings a similar course is followed, as far as piling and re-heating is concerned, but the mechanical operations are carried out under the steam hammer. The forgings of the highest quality are made from scrap iron to commence with; this is piled and welded into blooms, which pass through the breaking-down mill. The bars are cut up into equal lengths, and piled with great regularity in alternate layers crossing each other at right angles and diagonally. This pile is then brought to a welding heat, and hammered down into a bloom of the suitable size for the forging to be made from it. Forgings of an intricate shape take a very large number of heats before being finished, the average quantity of fuel which is used in a forge for this kind of articles being 9 to 10 tons of coal per ton of finished forgings. This consumption includes the total quantity of coal used in working the scrap iron, and that employed for making steam for the hammers and rolls.

The quantity of scrap iron employed in the production of a heavy and intricate forging averages about double the weight of the finished article. Some very fine forgings are just now in hand at the Parkhead forge, amongst these a stern-post for the Dutch frigate now in course of construction at Messrs. R. Napier and Son's shipbuilding yard, and two projecting bearings for the twin screws of the same vessel. For finishing articles produced in the forge, this establishment is provided with a very complete set of engineers' tools of very large size. A vertical drilling and boring machine, by Messrs. G. and A. Harvey, of Glasgow, is one of the largest of its kind in existence; and there are also a very large slotting-machine, by Messrs. Shanks and Co., a shearing-machine, by Messrs. Youle and Co., of Glasgow, with blades 6 ft. in length, some large planing-machines, and other tools of smaller sizes. The rolling-mill proper, which is placed in the same line with the breaking-down mill, but at the opposite side of the engines, is principally employed for making plates. The rolls are 24 in. diameter, 6 ft. 6 in. long, and the mill has a reversing gear, operated by a double clutch, which can be displaced by means of a long lever. The plates are rolled to a length of 15 ft., and to a weight exceeding 1 ton. There is a second plate-mill, with 22 in. rolls, attached to the same engine, this mill being said to be capable of working all the three mills simultaneously. Each plate-mill consists of one pair of soft rolls and one pair of chilled rolls, for finishing the surfaces of the plates. Another pair of rolls, 26 in. diameter, forms the armour-plate mill of the establishment, which has supplied a considerable quantity of armour-plates to the shipbuilders on the Clyde. The Parkhead forge is capable of employing 600 hands. Its rolling-mills can produce about 1000 tons of plates per month, and the forge is capable of turning out about 150 tons of forgings of all kinds per week. The quality of its products has a very high name in the markets, not only of Scotland, but also of the more distant manufacturing districts, and in foreign countries.

LOCOMOTIVE ECONOMY.

THE interest upon the cost of the early locomotives bore but a very minute proportion to their working expenses; but now we have so lessened the latter that one of the few remaining means of economising—we say “few,” because locomotive superintendents really see but few—consists in keeping an engine as long as possible upon the road, not merely to save in repairs, but so that a given service may be performed by the least possible number of engines, thus saving the interest upon the cost of an additional number. The annual interest at 5 per cent. upon the cost of a first-class engine (2800*l.*) is 140*l.*, or 33,600 pence, and as the average annual mileage of all engines, goods, and passengers hardly exceeds 16,800 miles, this amounts to 2*d.* per train mile, or as much in many cases as the whole cost of fuel, more than the wages of enginemen and firemen, and nearly as much as the total mileage cost of repairs.

The engine which is kept going and out of the shop the longest will not only save in interest on locomotive stock, but will, of course, cost less also for repairs, and will lose less in depreciation also, which must be taken, irrespective of repairs, as at least 5 per cent. yearly, making 2*d.* more per train mile, or 4*d.* including interest. For the value of any locomotive, worked as engines are now worked, may be considered as extinguished in twenty years, if indeed it will wear fifteen. We do not speak of old pensioners, retained upon the establishment in consideration of years of former service, and which manage to run branch trains, or do a little shunting, after twenty-five years’ buffeting with life on the road, but of the hard-going breed of engines, worked as locomotive superintendents work them in 1867—engines of 30 tons weight and upwards, with 14 tons or more on a single pair of wheels, working train of 140 lb. to 160 lb., and running express trains at 50 miles an hour, or heavy coal-trains at 25—work that would have astonished even George Stephenson, who, “fast” engineer that he was in 1829, was, in sober truth, among the slowest in 1845. He left fast engineering to Brunel and other gentlemen of kindred genius.

There are, even yet, locomotive engineers who believe that the question of locomotive economy is included in that—the broader question—of inside-cylinder and outside-cylinder engines, or that of bogie-engines, or other distinctive features of locomotive design. When Mr. Sinclair was engineer to the Great Eastern Railway, he would have only outside-cylinder engines, while Mr. Johnson, his successor, will have only inside cylinders, thus adding, again, to the needless variety of types of engines with which that unfortunate line is afflicted. Mr. Ramsbottom has given both classes a fair trial, and we believe he now inclines to inside cylinders. On the Caledonian, with its gradients of 1 in 75, some of the engines have 8 ft. 2 in. wheels, and these, with the driving-axle beneath and not behind the boiler, as in the Crampton engines, are almost necessarily outside-cylinder engines. Indeed, the outside-cylinder type is retained, and is, for the most part, still preferred, upon all the lines laid out by Joseph Locke—the old Grand Junction (northern division of the London and North-Western), the London and South-Western, the Caledonian, and yet, to a certain extent, on the Western of France. Abroad, indeed—with some exceptions in France and Germany—outside-cylinder engines are everywhere preferred, and in America inside cylinders are looked upon as relics of barbarism, no engines of that kind having been built for years. Properly counterweighted, and with the cylinders horizontal, the outsiders are in all respects as steady as the insiders, and they weigh a little less for the work they do, and have rather less working friction. If the cylinder fastenings are as strong as they should be, and the journals of the driving-axle are large and long, outside-cylinder engines can be kept up as cheaply as inside engines, even where the latter have steel cranks. As in Mr. Ramsbottom’s outside-cylinder engines, the journal and the part of the axle in the wheel-boss should be larger than the rest of the axle, so that if a break *does* happen (it need not with steel axles) it will be neither in the journal nor in the wheel-boss. Eight-inch journals 12 in. long are none too large for the driving-axle of an outside-cylinder engine with 17 in. cylinders, the strain from the steam being applied at a greater leverage than with inside cylinders.

The time is not very distant when no engine, unless it be all-coupled, will be worked without a bogie. True, this may be after the retirement of certain hard-headed unbelieving engineers, who think it discreditable—to use no stronger term—ever to change their opinions, and who prefer to think themselves infallible, although

others may not. The engine that is the easiest on the road is the best engine, other things being equal, and, with a weak permanent way, it would soon be known that the bogie-engine, and *not* that with its single leading-axle square across the frame, was the easiest. And what is necessary for a weak road is good, although not necessary, for a strong road. None who have ever worked bogie-engines would now work any other. Let whoever doubts ask Mr. Adams, of the North London, Mr. Cowen, of the Great North of Scotland, Mr. Burnett, of the Metropolitan, Mr. Eaton, formerly of the London and South-Western, but now of the Grand Trunk of Canada, and any and every locomotive superintendent in the States, where our single leading-axle, square across the frame, would not be tolerated for a week. Not only would our locomotive superintendents find that the bogie would save greatly in the wear of flanges, but that it would punish the road much less than the old leading wheels. It would admit of a much longer wheel-base, with greater ease in curves, and thus give a steadier engine; and it would save inclining the cylinders, and a great deal of overhang in outside-cylinder engines. The Bissell bogie is far better even than the ordinary pivoting bogie, and Mr. Adams, of the North London, leaves his bogies to move as they like, his engines being really guided by the flanges of the driving and trailing wheels.

There is little now to be said about coal-burning. Most of our locomotives now burn coal, but not always, nor perhaps often, without smoke. Smoke can be, and *should* be, prevented however, and its prevention lies as much with the driver as in the construction of the firebox. Coal slack, that despised material, is still cheaper than lump coal, and why should not we burn it, as M. Belpaire does on the Belgian railways? Mr. Cudworth’s long inclined grates, if made with very narrow bars and air spaces, say $\frac{3}{4}$ in. bar to $\frac{1}{2}$ in. space, would burn slack perfectly. One essential condition is that of a large grate, say 24 square feet, where coal would require 15 or 18 and coke 12 square feet. We are not sure, either, whether locomotive engineers have gone into the question of coking slack, with or without washing. A few years ago the idea of washing out the slate and pyrites from slack and then coking it was ridiculed. James Morrison, of Newcastle, made a fortune, however, by taking up the matter with Bourdon’s coal-washing machines; and now, and only now, after the patent has expired, are the Welsh ironmasters beginning to wash coal slack and to use the coke for making pig for Bessemer steel, the fuel being so much purer than ordinary coke made from unwashed coal. We think that, although three tons of slack would be required to make two tons of coke, coked slack would be cheaper than lump coal, although not, of course, so cheap as slack itself.

Among the leading questions for locomotive superintendents just now are the introduction, as far as possible, of steel castings in place of cast-iron, and that of welded as compared with rivetted boilers. Steel can now be cast to any shape; indeed the Bochum Company (whose works are near Krupp’s) exhibit in the Paris Exhibition not only a single casting of twenty-two railway wheels clustered upon one stalk, but a locomotive cylinder. So long, however, as east-iron cylinders, as now got up, will go four years without re-boring, and can then be re-bored *in situ* by means of a cheap portable tool, we hardly need steel. But steel castings, now so extensively made in Sheffield by Vickers, Sons, and Co., are applicable to many parts of locomotives, especially for horn blocks, pistons, &c. The piston of the large steam-hammer at Sir John Brown and Co.’s is of cast steel, very light, and the same makers (above named) are this week sending a pair of steel pistons for a locomotive to the engineer of the Great Western Railway of Canada—not that any English locomotive superintendent has yet performed such a daring feat as even to try a material, for this purpose, which, his common sense and ordinary knowledge must convince him, is better than either cast iron, wrought iron, or gun-metal.

So long as we rivet the longitudinal seams of boilers, instead of welding them, so long shall we keep down the real strength of locomotive boilers to two-thirds that which they might have with the same plates. The subject of welded boiler-rings, whether welded by Bertram’s mode or in the ordinary fashion, as in Stephenson’s engine in the Paris Exhibition, or rolled out in a single piece, as has been done by Shortridge and Howell, by Krupp, and others, is one of the very first importance for locomotive engineers, and it must be taken up, broadly, as bearing upon the probable future use of steam of 250 lb. per square inch. And while boilers are rivetted and double rivetted, as is

now frequently done, the double lines of rivets should be zigzagged, instead of being placed, as is often the case, one rivet behind another; and where outside and inside cover-plates are used, as some engineers are now using them, it should be remembered that the rivets are in double shear, and that smaller rivets than usual will therefore suffice.

Then, for the very high-pressure (160 lb.) steam used on some lines, we need metallic packing in the stuffing-boxes. Hemp, cotton, and all the manufactured substitutes, however good they may be, must yet be looked upon as crude apologies for metal. We have seen excellent white-metal packing for cylinder and valve-spindle stuffing-boxes, which has worked admirably for a long time, and which would have withstood steam of any pressure and temperature. The patent lubricators (Roscoe’s) are helping also to the use of steam of still higher pressure, and we are beginning to understand that it is a good plan to *oil the steam* before it touches any working surface whatever. And speaking of oil, it is quite time that our locomotive engineers tried petroleum lubricating oil, now so largely used in America. We do not mean that it should be at once *adopted*, but that it should be *tried*.

The slide-valves should be made to work with less friction than now. There is Mr. Thomas Adams’s plan, already widely tried, but we cannot say with precisely what results; and there are Bristol’s rollers, as introduced from abroad by Mr. Daglish, of St. Helen’s. These save something in valve friction, and are worth trying.

Locomotive engineers should address themselves most seriously to the question of continuous brakes, for the want of which so many terrific railway “accidents” are frequently occurring. They have been well worked out on the North London line, where the trains come into a station at the rate of 25 miles an hour, and are stopped, short, before the engine passes the further end of the platform. Taking the friction or adhesion of the wheels to the rails as one-sixth the weight, and supposing every wheel of a train locked, it should be stopped, at 60 miles an hour, on a level, within a distance of 242 yards, and, at 30 miles an hour, within 60½ yards. No subject, perhaps, is better worth the best attention of locomotive superintendents than that of continuous and instantaneous brakes. Public opinion will, sometime, condemn the present wild custom of allowing trains of uncontrollable momentum to go plunging headlong to destruction, as at Staplehurst, when the danger is sighted 500 yards off, and often much more.

There is nothing *now* to be said, after so many years of discussion, as to the use of the injector, as to expansion, feed-water heating, variable blast pipes, and that *ignis fatuus* of locomotive engineering, superheated steam. All these have been “pumped out” years ago, not but that they present ground for eternal argument, but it is best not to revive these arguments here. We do not court the strife, and would rather dwell upon those simpler and far less cholerical questions of fittings and locomotive details, of which so much may be made.

(To be continued.)

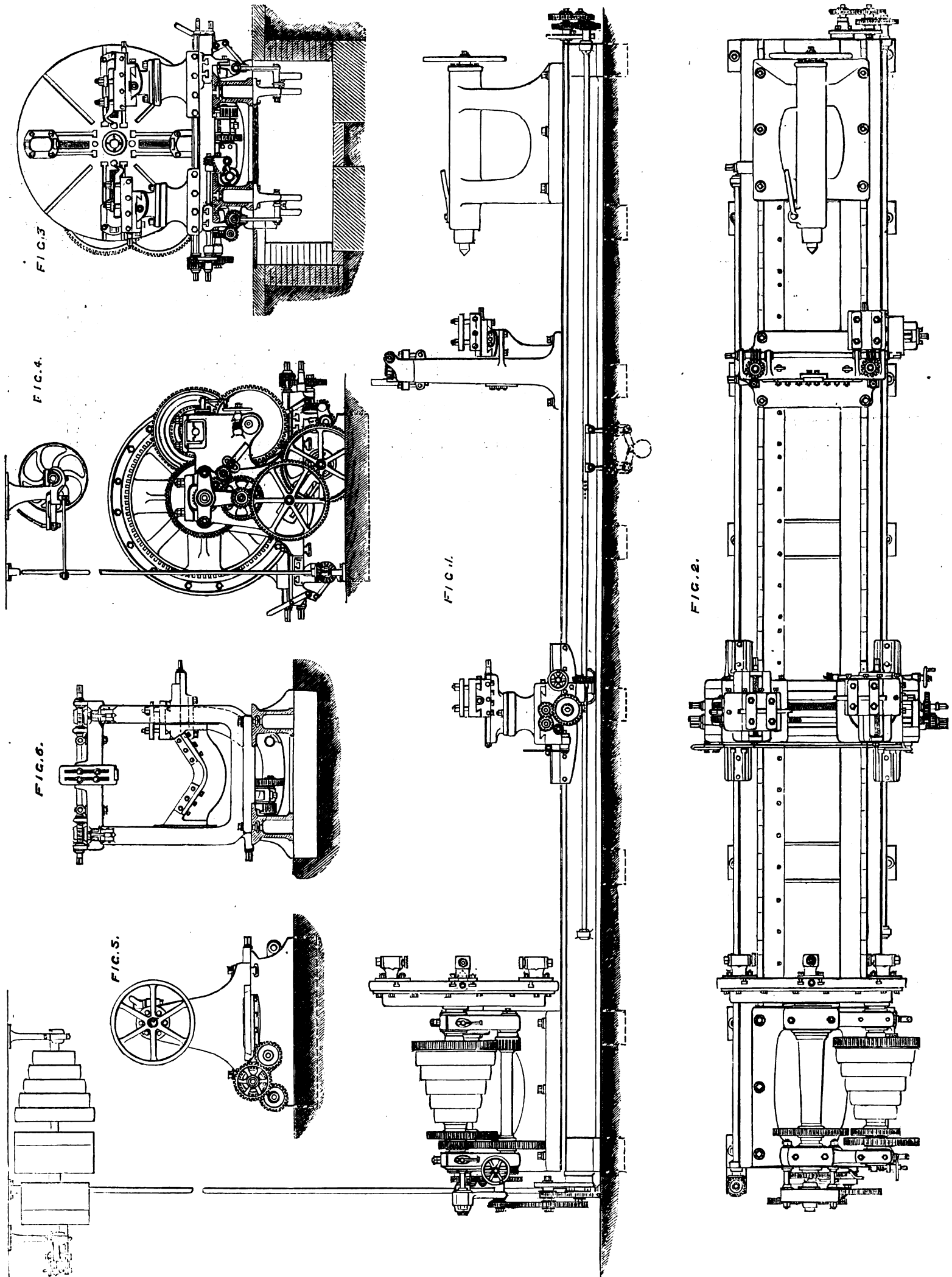
NEW SLIP AT MESSRS. INGLIS’S SHIPBUILDING-YARD.—This slip, which is the largest on the Clyde, has been recently finished. It is 850 ft. in total length, and capable of accommodating ships up to 2000 tons measurement, and drawing up to 16 ft. forward. The vessel at present upon this slip is the St. Patrick, belonging to Mr. Allen, of Montreal. She is 230 ft. long, 33 ft. beam, and 22 ft. deep; she has been hauled up, with her engines and boilers on board, and with some 200 tons ballast in the hold, for the purpose of having a new screw fitted, the old screw having been broken. The weight of this vessel in her present state is 1600 tons. The slip is worked by a 20 horse power engine and a hydraulic ram; the latter has a cylinder 14 in. in diameter, with a stroke of about 6 ft. The carriage of the slip is drawn up the incline by a double chain having long links at its upper end. The stroke of the hydraulic press corresponds to the length of one link, and the chain is shortened by one link after each stroke of the press. The carriage is meantime held in its proper position by a claw, which acts against a toothed rack in the centre of the slip, and extending all over the length of the inclined plane. This rack is made of cast iron, and its teeth are considerably deeper than usual. We expect very shortly to publish complete drawings of this interesting work.

BARCELONA.—Considerable works are being executed at Barcelona, the most considerable port of Spain, on the Mediterranean. The depth of water is being increased to 33 ft., and the port will be protected by two jetties to the east and the west, so that it will comprise altogether a space of 286 acres, into which ships of the heaviest burthen, even war frigates, will be enabled to enter. The cost of these works is estimated at 450,000*l.*

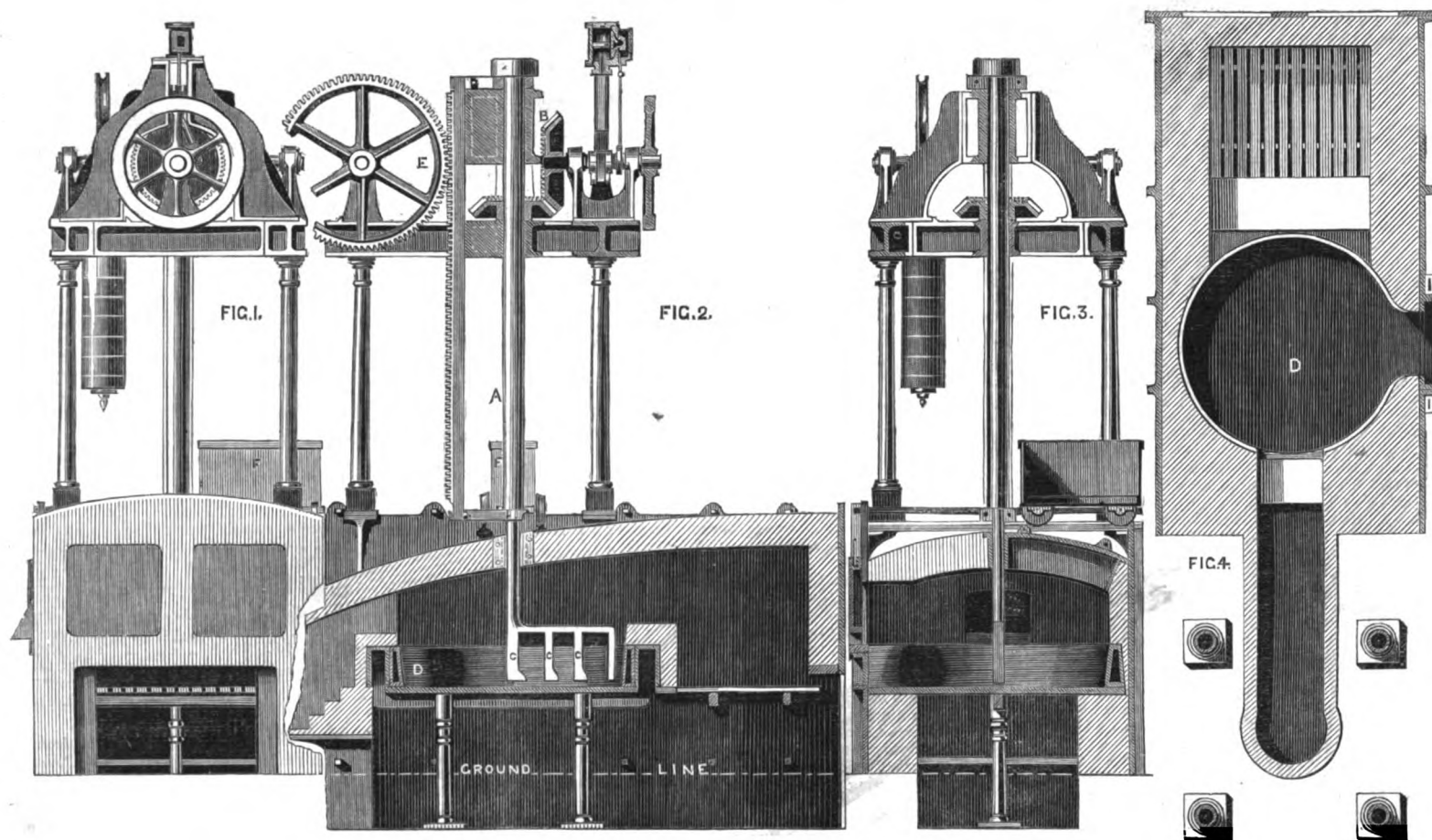
CHAMBERS OF INDUSTRY.—A chamber of industry is proposed to be established at Leeds. The object of the chamber is to act as a general board of arbitration and conciliation, and to endeavour to bring capital and labour into a closer union.

LATHE FOR TURNING CONICAL SURFACES AT THE PARIS EXHIBITION.

CONSTRUCTED BY MESSRS. DUCOMMUN AND CO., ENGINEERS, MULHOUSE.

(For Description, see the opposite Page.)

MORGAN'S PUDDLING FURNACE.



MORGAN'S puddling-machine, of which we give engravings above, consists of a vertical shaft, A, worked by bevil gearing, B, and entering into the roof of the furnace in the centre of the working part. The shaft is continually revolving when the iron is in a liquid state. Fitted into the bottom of the shaft is a common tool furnished with four fangs, C, each one capable of doing the work of the well-known ordinary puddlers' "rabble." This tool, moving at a tolerable velocity, exposes the liquid iron to the influence of the oxygen passing through the furnace, D, until the iron obtains such consistency that it requires the puddler's skill to form it into the required number of balls ready for the hammer or squeezer as the case may be. The rack and pinion, E, worked with the balance weight, G, are employed to raise the "rabble" through an opening in the roof, which is immediately closed by a fire-brick cover cased in a cast-iron frame, and conveniently arranged for the puddler to move out and in when required. After the "rabble" is hoisted, and the opening through which it has come is closed as above, a "boosh" or small truck, F, filled with water, is run under, and the heated tool is immersed in it, and thus cooled ready for again carrying forward its useful internal operation of dashing about the molten iron when it is required to do so.

It will be seen, from the above description, that the machine is simple in its construction, is entirely out of the way of the puddler, takes up no more room, so that any alteration in the present forces will be unnecessary. One engine may easily work several of these machines; and the arrangements may be such that the most ignorant workman can carry out all the operations required.

The furnace will require to be altered only in the working part, making it circular instead of being oblong. The bottom and air-passages will be the same as used at present.

By introducing this patent puddling-machine and furnace, it is not intended to altogether supersede manual labour in producing the balls ready for the hammer, but to take the labour out of the hands of the workman when his skill is not necessary, and when he is obliged at present to stand, say, thirty or forty-five minutes in each heat as a mere machine before a partially open furnace, which is felt to be a trying thing at any time, but is especially irksome when a man's skill is not required, and he is conscious that he is but a piece of machinery for the time being.

Whatever may be discovered in the future to improve upon this machine, it is conceived that a step is taken by it in the right direction, and, from the opinion of many practical men of high standing, it is considered to be a very important step.

In the selection of workmen as puddlers it is, under the present mode, difficult to find men with the united qualities of skill and power of endurance, so that any diminution of the manual labour is of the greatest moment; for it is obvious that to employ the men where skill predominates is a great advantage beyond using them for mere physical force and power of enduring heat. Numberless instances might be brought forward to show the stern necessity there exists for something being done by machinery to lessen the exposure of the puddler, such as the workmen dropping down before the furnace, as they frequently do, the large numbers on the sick list, as well as the numbers of men who, in the close hot days, dread

returning to their labour, knowing beforehand what they have to suffer, not to say endure, under such circumstances.

Such a machine as the above, with even its humble pretensions as an alleviator, will, when universally adopted, secure a superior race of skilled workmen as puddlers, and such a consummation has been a long time devotedly wished for by those whose occupation has led them to think most deeply, and to employ themselves most actively in the manufacture of iron. Lighten the labour, and the present wages will tempt the best and most intelligent of the population to come forward in greater numbers, and thus restore the iron trade of this country to the pre-eminence it claimed some forty years ago, when English puddlers were sought for by every country in which iron was made.

The economic value of a puddling machine can be seen only by taking a review of the whole process of puddling. Every practical ironmaster is fully aware of the importance of this department in iron-making. It is here where the iron is brought either to the perfection required or altogether spoiled. In grey iron this is more especially felt; as to have the full value in quality that ought to be obtained, the iron should be brought up to the boil while the furnace is in the most intense heat, and without lowering the damper for a moment; this carried out, the result is that you rarely or ever have an inferior quality produced, but generally the reverse is the case, no sooner is the iron melted than the damper is lowered, and the furnace brought to a dark red heat, besides which the puddler in numberless cases throws into the molten iron a quantity of wet slag or scale, bringing the iron into a fictitious boil, poisoning the result of his labour, producing a cold, short, and almost useless iron. And all this is done by the men, in spite of the strictest oversight, to reduce the fearfully excessive manual labour required so continuously, and which the puddler finds to be unbearable under the circumstances, although he feels he must get his five or six heats out in the specified number of hours allotted to him for that purpose.

To obtain the first result always, and to avoid the latter, are the great desiderata a puddling-machine is required to accomplish.

This much-to-be-desired result of bringing the iron in the puddling furnace up to the boil while the furnace is at the greatest heat, can be done effectually only by some such machine as is here described. It accomplishes in the best way what is absolutely necessary, viz., that of rapidly stirring or throwing up the molten iron in the puddling furnace to come in contact with the oxygen, and get rid of the superfluous carbon the iron contains, also to cleanse it from various injurious impurities generally found in combination with iron.

It is found that two important results are secured by this process being accomplished with rapidity. The first is the saving of the felling lining the furnace, as the longer the iron remains in the thin liquid state the more the felling is eaten away, causing not only additional cost for material, but also additional labour to the puddler to replace what has been destroyed. The second is the time saved, first, in bringing the iron up to the boil sooner than can be done at present, second, from the less frequent necessity there is for relining

the furnace. This saving of time will most assuredly increase the production of iron from every puddling furnace in the kingdom where it may be adopted.

There must therefore be a considerable saving to the manufacturer in cost, not to speak of the very greatly improved quality of the iron that may be manufactured by it in any district, especially that of the Cleveland.

The fact is, machinery must be further applied in the successful manufacture of iron; and the attention of the ironmasters is called to this machine as worthy of their consideration, as it is a step in the direction which the present state of the trade in this country loudly calls upon us to all travel.

DUCOMMUN'S LATHE.

AMONG the machine tools exhibited by French makers, none appear to us to show off to better advantage, in a comparison with tools of French make, than those of Ducommun and Co., of Mulhouse, one of the oldest French firms in the trade, and this both on the score of design and excellence of workmanship.

We therefore purpose illustrating a few of those machines exhibited by them which possess a certain amount of originality; and in the engravings on the opposite page, we have illustrated a heavy sliding-lathe, provided with apparatus for screw-cutting and for turning true conical surfaces, and designed principally for turning heavy marine work and heavy guns.

The bed, which is cast on the box principle, is about 40 ft. long and 5 ft. wide measured over the V's; the height of the centres is about 3 ft. 5½ in., thus admitting an object of about 7 ft. diameter.

The fixed headstock is double geared, provided with internally toothed face-plate, and quick motion direct through the lathe spindle. The cone shaft, whose bearings are made to slide horizontally towards and from the centre of the lathe-bed, may be thrown out of gear with the face-plate by means of two set screws, and at the same time a small pinion, which it carries, is thrown into gear with the wheel on the main spindle, when it is intended to run at quick speed. The intermediate shaft, through which motion is communicated to the face-plate when taking heavy cuts, revolves in eccentric bearings, and is thrown out of gear by turning these bearings round upon their own centre by means of a worm and worm-wheel. We would here observe that the tendency of this shaft being to fall back into the position of greatest stability, the worm-wheel ought to be provided with some kind of stop to prevent the shaft from being thrown out of gear by the jar of the wheels in motion.

The main spindle rests in cylindrical bearings, and is fitted with a thrust pin behind, in preference to the conical bearings so largely adopted in this country; and in reference to this, we may state that Mr. Beyer (of the firm of Beyer, Peacock, and Co.) has always advocated this practice in the case of very heavy lathes.

The screwing motion is derived from the lathe-spindle in the ordinary manner; but by means of a very neat arrangement of a lever pivoting upon a stud, and carrying permanently two equal pinions which gear into each other. The reverse motion of the screw for cutting left-hand threads may be obtained by causing one or the other of these pinions to gear into the first of the train of wheels that drive the screw with a slight motion

of the lever only, and without the trouble of introducing an intermediate pinion, which has to be removed again.

The propriety of fitting a heavy lathe like this with a screw-cutting motion might here, with an apparent show of reason, be called in question, but it will be seen presently that the screw has been introduced especially to meet the condition of turning true conical surfaces, which was imposed upon the maker by the officials in command of the French arsenals.

The longitudinal sliding motion is derived directly from the screw, but the slide-rest may be moved by hand through a pinion gearing into a rack fixed to the underside of the top table of the lathe bed, in which circumstance the nut is disengaged from the screw by means of a worm and worm quadrant working a system of small levers.

The slide-rest carries two cross slides, each worked by an independent screw, by means of which arrangement two cuts may be taken simultaneously at opposite sides of the work; these cross slides are also moved indirectly by the main screw through a train of wheels. The first of which is fixed to the end of the former, where it projects through the lathe bed; motion is thus given to a shaft which carries a sliding wheel which drives a worm and worm-wheel, and, by means of a small spur-wheel, which gears into one of the small pinions carried by the screws of the cross slides, these are moved simultaneously either towards or away from the centre of the lathe bed.

It is by means of this arrangement that the lathe is made to turn strictly accurate conical surfaces; and by reversing the motion of the main screw by the simple arrangement above described, the lathe may be made to work both backwards and forwards, whether the surface, being turned, be cylindrical or conical, while, by changing the ratio of the wheels through which the cross-slides derive their transverse motion, the taper of the cones may be varied at will. It may now be observed that it is this desideratum of turning a true conic surface which has led to the adoption of the screw for working the main slide, and to the necessity of obtaining the transverse motion of the cross slides from the main screw, instead of adopting the more common method used in slide-lathes of working the main slide by rack and pinion from the main spindle direct, by a belt running upon small cones, because the forward motion obtained by the rack is less perfect than that obtained by the screw, and the slip of the short belt would destroy the synchronism of the motions of the several slides with the circumferential speed of the piece of work to be turned.

The lathe is also provided with a saddle-rest, in which the work being turned is held in position by three adjustable guiding edges, the saddle proper being moved up or down by means of a couple of worms, worm-wheels, and screws. A small compound-slide rest is also fixed for the purpose of facing or shaping the end of the piece of work in the lathe; the saddle-rest also may be moved along the lathe-bed by a pinion gearing into the rack.

The loose headstock is of the usual construction, and may also be moved by means of pinion and rack.

The reversing and stop motion of the head-gear may be worked from the slide-rest in all its positions on the lathe-bed, by means of a system of levers and rods, which communicate an angular motion to a horizontal shaft, and this through a pair of bevel-wheels to a vertical shaft; a lever which is keyed upon this works a sliding-rod fitted with forks, which shift the belts from the fast on to the loose pulleys, or vice versa. This piece of machinery seems rather expensive, but is very neat.

The face-plate is provided with four adjustable dogs, and in all other respects no expense has been spared to ensure durability in the machine, and accuracy in the work to be performed, all the bearings of the screws and shafts being bushed, and all parts which are subject to blows and undue wear being case-hardened.

In our illustrations on page 338, Fig. 1 is a longitudinal elevation, Fig. 2 a plan, Fig. 3 a cross section showing the slide, tool-rests, and face-plate, Fig. 4 an end elevation of the fast head-stock, Fig. 5 an end elevation of the loose head-stock, and Fig. 6 a cross section showing the saddle-rest.

TRACTION RESISTANCES ON RAILWAYS.

At the meeting of the Société des Ingénieurs Civils de France, held on the 13th of last month, M. Flachet, the president, mentioned that a competition had been started by the late M. Perdonnet for the best paper upon the practical conditions affecting the haulage of railway trains. In consequence of this competition a very important paper had been presented by M. M. Vuillemin, Guéhard, and Dieudonné. Before the report of the council, elected to decide upon the merits of the works presented, should be read to the Société, they desired that this paper and its results should be made known; and the authors had, therefore, prepared a résumé for the meeting of that evening. M. Vuillemin, being engaged in the superintendence of the locomotive department of the Eastern Railway, his place was taken by M. Dieudonné.

M. Dieudonné commenced by remarking that the experiments undertaken by the Eastern Railway Company answered most of the questions comprised in the programme determined upon by the Société des Ingénieurs Civils, in February, 1866, for the competition started by M. Perdonnet. Thus the first was: "To determine, by numerous experiments, the tractive resistances of vehicles and locomotives upon railways, under all the varying circumstances which could modify these resistances, such as

- "The state of the rails, of the vehicles, and of the engines;
- "The intensity and direction of the wind;
- "The surface exposed by the carriages and the length of the trains;
- "The dimensions of the axles, bearings, and of the wheels;
- "The nature of the oil or grease employed for lubrication;
- "The temperature, the mode of coupling;
- "The method of loading;
- "The system of construction of the engines;
- "The friction of the mechanism;
- "The coupling of the wheels;
- "The effect of inclines, curves, &c."

To determine the tractive resistances of vehicles, M. Dieudonné stated that two methods had been employed.

First Method.—The vehicle, of which it was desired to determine the resistance, was launched upon the line at a speed that had been determined upon, and was then allowed to run without interference, until it was brought to rest by friction, &c., the distance run being measured.

Let m = the mass of the vehicle,
 v_0 = its initial velocity in metres per second,
 x = the average resistance during the run (in kilogrammes).

If the line was level there would be the following equation:

$$(1) \quad \dots \quad \frac{1}{2}mv_0^2 = x \cdot s,$$

from which x , the mean value of the resistance, could be determined.

The equation (1) required to be completed by a term which took into account the rotative momentum of the wheels which tended to urge the carriage forward. M. Dieudonné stated that the detailed calculation for determining this correction was given in a separate note, and that it had been found that for a carriage it was necessary to introduce into the first side of the equation the term $25 \times v_0^2$, the equation thus becoming

$$(2) \quad \dots \quad (\frac{1}{2}m + 25v_0^2) = x \cdot s.$$

This method of investigation also leads further, that is to say, to the determination of the resistance at any given speed, or of the tractive power which would have to be applied to the vehicle to maintain it at that speed. Let us suppose that there has been noted, during the slackening of speed of the carriage, the spaces passed through in given periods of time; then a curve can be laid down, so that these spaces form a function of the times,

$$s = f(t).$$

Draw tangents to this curve at various points, and measure the angles formed by these tangents with the axis of abscissæ, then the geometrical value of these tangents, measured with a circle having a radius equal to unity, gives the speed at the various points. A curve can then be traced,

$$v = f'(t).$$

By operating in the same manner upon the second curve there may be deduced the curve of accelerations,

$$j = f''(t).$$

By multiplying the acceleration, j , at any instant fixed upon, by the mass, m , there can be obtained the force applied,

$$F = m \times j''(t).$$

Then, having constructed the curve of acceleration it is sufficient to multiply its ordinates by a constant, m , to obtain the retarding force at different instants.

Second Method.—The second method of determining the resistances consisted in experimenting with a traction dynamometer. The dynamometer employed in these experiments had a spring with fourteen plates 3 ft. 5 in. long. These plates were bent over at their ends so as to form eyes, and each plate was connected to that next to it by bolts and shackles. The arrangement was such that either the whole spring, or only part of it, could be used according to whether the tractive force required was more or less great. The deflections of the spring under different loads were carefully ascertained in the workshop and noted, a scale being made out for each strength of spring, one for two plates, one for four plates, and so on. The deflections were found to be very nearly proportional to the force applied. The fact of its being possible to use a greater or less number of plates rendered the deflection per 1000 kilogrammes (2200 lb.) sufficiently great to be at all times read with facility. The spring was both strong and sensitive, and it was found that its elasticity did not alter during the experiments.

Resistance of a Single Carriage.

The carriage upon which the experiments were made had a closed body carried on four wheels, and the axles were lubricated with oil. Its weight was 5500 kilogrammes (12,100 lb.). The line was straight and level, and the weather was calm and dry, the temperature being 25° Cent. (77° Fahr.). Experiments were made by both methods.

The first method furnished the following coefficients of mean resistance for different initial velocities (application of formula (2)).

Initial Velocities.		Coefficients of Resistance.	
In metres per second.	In feet per second.	Kilogrammes per tonne.	Pounds per ton.
5.00	= 16.4	...	3.20 = 7.168
6.65	= 21.71	...	4.07 = 9.1168
13.90	= 45.59	...	7.88 = 17.0912
13.90	= 45.59	...	7.18 = 16.0832
12.50	= 41.00	...	6.03 = 13.5072

It will be seen from this table that the resistance increases with an increase in the initial velocities; if the initial velocity is doubled, the resistance is almost doubled also.

For calculating the resistances corresponding to various fixed velocities, the method of laying down tangents, as already described, was employed. The results obtained were as follows:

Speeds.		Coefficients of Resistance.	
In kilometres per hour.	In miles per hour.	Kilogrammes per tonne.	Pounds per ton.
35	= 21.7	...	7.6 = 17.024
25 to 30	= 15.6 to 18.6	...	6.3 = 14.112
20 " 25	= 12.4 " 15.6	...	5.4 = 12.096
15 " 20	= 9.3 " 12.4	...	4.3 = 9.632
10 " 15	= 6.2 " 9.3	...	3.4 = 7.616
5 " 10	= 3.1 " 6.2	...	2.5 = 5.6
1 " 5	= .62 " 3.1	...	2.0 = 4.48
0	= 0	...	8.7 = 19.488

The last figures give the resistance to starting.

The second method, or experiments with the dynamometer, gave the following values for the resistances of the same carriage:

Speeds.		Coefficients of Resistance.	
In kilometres per hour.	In miles per hour.	Kilogrammes per tonne.	Pounds per ton.
25	= 15.6	...	4.54 = 10.1696
50	= 31	...	9.1 = 20.384

The first of the above resistances is slightly less than determined by the first method as being due to the same speed. The reason of this is doubtless that, in the course of the

second experiments, the front of the carriage was partially shielded by the tender.

The coefficient of resistance to starting, 8.7 kilogrammes per tonne (19.488 lb. per ton), was approximately verified by means of a small dynamometer with a spiral spring, attached to a chain, by which a hauling power was gently applied to the carriage until it was just made to move.

Resistance of Locomotives.

The locomotives experimented upon were in road-worthy condition, and they were accompanied by their tenders, which carried their ordinary loads.

The line was straight and level, and the temperature was about 20° Centigrade (68° Fahr.).

First Method.—The engines, propelling themselves, were run at certain determined velocities; and, as soon as the speed had become uniform, the regulator was closed, and the engines were allowed to run freely until they came to a complete stand. The times and the spaces traversed were measured by means of a chronometer and a distance measured.

An equation of the same form as equation (2) enables the value of x to be calculated, or, in other words, the mean resistance during the period of slackening speed to be determined. By dividing this mean resistance by the combined weight of the engine and tender, the mean resistance per ton can, of course, be obtained.

The engines submitted to this series of experiments were of two classes:

1st. Mixed engines, with four coupled wheels 1.7 metres (6 ft. 1 in.) in diameter; weight 30 tons; cylinders 42 centimetres (16.53 in.) in diameter.

2nd. Goods engines with six coupled wheels 1.3 metres (4 ft. 3 in.) in diameter; weight 30 tons; cylinders 42 centimetres (16.53 in.) in diameter.

The values found for the coefficients of mean resistance were as follows:

Initial Velocities.		Coefficients of Resistance.	
In kilometres per hour.	In miles per hour.	Kilogrammes per tonne.	Pounds per ton.
20 to 25	= 12.4 to 17.98	...	3.2 = 7.168
30 " 35	= 18.6 " 24.18	...	4.0 = 8.96
40 " 45	= 24.8 " 30.38	...	4.35 = 9.744
50 " 60	= 31.0 " 37.2	...	6.7 = 12.768

Initial Velocities.		Coefficients of Resistance.	
In kilometres per hour.	In miles per hour.	Kilogrammes per tonne.	Pounds per ton.
20 to 25	= 12.4 to 15.5	...	5.32 = 11.9168
25 " 35	= 15.5 " 21.7	...	6.43 = 14.4032
35 " 40	= 21.7 " 24.8	...	7.52 = 17.8448

It will thus be seen that the resistances increase continuously as the initial velocities increase. The difference between the coefficients obtained at equal speeds from the two classes of engine is explicable from the difference in the mechanism.

Second Method.—In these experiments the dynamometer was interposed between two engines, the one drawing and the other being drawn. The engine that was being drawn had its regulator shut, its reversing lever placed in mid-gear, and its cylinder-cocks open. A steady speed was maintained for several consecutive kilometres in order to obtain good diagrams. Four classes of engines were experimented upon, and the coefficients obtained from the mean speeds were as follows:

Speeds.		Coefficients of Resistance.	
In kilometres per hr.	In miles per hr.	kilo.	lb.
1st. Goods engines, with six wheels coupled; weight, 20 tons ...	V = 24 = 14.98, f = 9.52	21.3248	
2nd. Goods engines, with six wheels coupled; weight, 33 tons ...	V = 26 = 16.12, f = 10.24	22.9376	
3rd. Mixed engines with wheels 1.7 metres (6 ft. 1 in.) in diam. ...	V = 45 = 27.9, f = 6.41	14.3384	
4th. Engine with single pair of driving wheels 1.7 metres (6 ft. 1 in.) in diameter ...	V = 45 = 27.9, f = 5.48	12.2752	

These numbers are naturally higher than those obtained by the first method, because the speeds were higher and the lubrication of the cylinders and slide-valves was less perfect. Thus, in these latter instances the engines ran several kilometres without steam being admitted into the cylinders, whereas in the former cases the distances run after the regulator was closed were a few hundred metres only, and the extra friction due to the want of the lubricating action of the steam was consequently less. More will be said of this presently; at present notice may be taken of two applications of the foregoing results:

1st. At their normal speed goods engines with six coupled wheels will descend alone, and without steam, inclines of 9 and 10 millimetres per metre (1 in 111 and 1 in 100). Mixed engines, and engines with single pairs of driving-wheels will similarly descend inclines of 5 and 6 millimetres per metre (1 in 200 and 166).

2nd. The figures given by the first method may be used for calculating the brake power required to bring the engine to a stop in a given distance, the initial speed being known.

(To be Continued.)

ITALIAN RAILWAYS.—The Italian Government is pushing forward the construction of a line to unite Marseilles, Genoa, and Leghorn, *via* the littoral of the Mediterranean. It appears from a letter addressed by the Minister of Public Works to the syndic of Genoa that the number of workmen now employed between Savona and Pesti is 4700. It is hoped that a section from Genoa to Chiavari will be opened for traffic in the course of November.

FAIRLIE'S MOUNTAIN LOCOMOTIVE.

In designing rolling stock for mountain railways having steep inclines, there are two principal points which claim special attention. The first of these is to reduce the dead or unpaying weight of each train to the least possible amount, and the second is to place on the coupled wheels of the locomotive, by which the train is to be drawn, as great a proportion of the total weight as is practicable. Now there is no way in which these two ends can be obtained so perfectly as by placing the load to be carried upon the locomotive itself, and thus rendering the whole weight of the "train" (as we may still call it) available for adhesion. Moreover, this plan in no way interferes with the practicability of giving the "train" all the flexibility required to enable it to travel with perfect ease all the sharp curves with which mountains must almost necessarily abound. The system of loading a kind of combined carriage and locomotive with passengers and goods has several times been suggested by us in this journal, and, as we mentioned last week in our article on "Mountain Locomotives" (*vide* page 326), Mr. Fairlie some years ago hit upon the same plan.

We have now by us a tracing showing a combined locomotive and carriage on this principle, sketched by Mr. Fairlie some years ago, and this design we reproduce in our engravings on the next page. The "mountain locomotive" shown in these engravings is one of Mr. Fairlie's well-known double-boiler engines, provided with two six-wheeled steam bogies, each bogie having a pair of cylinders 11 in. in diameter, with 16 in. stroke. The diameter of the bogie wheels is 2 ft. 8 in., and the wheel base of each bogie is 6 ft. 8 in., whilst the extreme length between the centres of the outside axles of the two bogies is 25 ft. 1 in. Instead of the boiler having the usual footplate on each side of it, Mr. Fairlie completely covers in each barrel by either a carriage or wagon body respectively capable of being used for the conveyance of either passengers or goods. In our engravings both barrels of the boiler are shown enclosed in passenger compartments; but the two ends of the engine might, if preferred, be respectively devoted to the conveyance of passengers and goods.

Between the bodies or compartments, by which the boiler barrels are covered, is formed a raised platform, on which the driver stands, this platform being sufficiently elevated to enable the man to have a clear view over the roofs of the carriages in every direction. The platform is roofed over, and the spaces between this roof and the roofs of the carriage bodies are glazed. The regulator handles and the wheels by which the reversing gear is worked are placed so that they are readily accessible to the driver in whichever direction he is looking out. The fireman stands on a platform provided at the usual level, the firing being performed through a door at the side of the firebox. The connexion between the bogies and the upper frame, and the arrangement of the steam and exhaust pipes, are the same as in Mr. Fairlie's other engines, which have several times been described in this paper. The water is carried in tanks, having a combined capacity of 1000 gallons, placed under the footplate on each side of the firebox, and the fuel is accommodated in bunkers formed at each end of the fireman's platform, as shown in the engravings.

So much for the engine; and now about the accommodation for passengers and goods. If constructed with a passenger compartment at each end, as shown in our engravings, the engine would carry sixty-eight passengers, besides affording ample space for their luggage. The compartments are about 10 ft. wide outside, and, as will be seen from the various views on the next page, each contains four rows of seats arranged longitudinally. Referring to the transverse sections, it will be seen that the floor of each passenger compartment is 2 ft. 6 in. above the ordinary footplate level, and that at this latter level another floor is formed, the spaces between the two floors being available for the stowage of passengers' luggage or goods. These four luggage spaces (two at each end) have a total cubic capacity of about 400 cubic feet, and access is gained to them by side-doors conveniently placed.

The two passenger compartments will, as we have said, carry sixty-eight passengers, the two outside seats of each compartment accommodating nine, and the two central seats eight persons each. The central seats are shorter than those at the sides on account of its being necessary to provide space for the chimney of each smokebox, these chimneys being surrounded by a casing. The central seats are, as will be seen from the transverse sections, placed over the boiler, but the communication of heat from the latter is prevented by an air space being formed between the seats and cladding. The rush of air through this space when the engine is in motion will, if the ends are left open, effectually prevent any heat from being transmitted from the boiler to the passenger compartment. The ends of the air spaces are, however, provided with shutters or venetians, and by closing these the passage of the air can be checked to any desired extent, and the heat of the boiler thus rendered available for warming the compartments in cold weather. We are aware that many nervous individuals will at first object to sitting directly over a locomotive boiler, but there is really no valid ground for the objection. On steamboats, thousands of passengers every day sit and walk about above the steam boilers without raising any objection to the presence of the latter, and there is no reason why a locomotive boiler should excite any greater nervousness than one used for marine purposes.

Again referring to the transverse sections, it will be seen that the roofs of the passenger compartments are made in two spans. This system of construction has been adopted in order to give the greatest height over the passages between the seats, and to at the same time lessen the height of the roof at the centre of the carriage, so as to give a clear look out for the driver. The compartments are entered from the outer ends, there being a platform with steps at each end of the engine, as shown in the side elevation.

Having described one of Mr. Fairlie's plans, as illustrated in our engravings, we must now say a few words respecting the principle on which these plans are founded. This principle may be very simply explained by an example. Supposing that the resistances due to friction and other sources, irrespective of gravity, amount on a mountain line to 20 lb. per ton of train, this will make such resistances equal to $\frac{1}{12}$ of the load. On

an incline of 1 in 12 there will be an additional resistance due to gravity amounting to $\frac{1}{12}$ of the load, making the total resistances $\frac{1}{12} + \frac{1}{12} = \frac{2}{12} = \frac{1}{6}$ of the load. On an incline of 1 in 12 also, the pressure of the load upon the rails would be diminished to $\frac{11}{12}$ of its total weight, and this $\frac{11}{12}$ therefore would be all that was available for adhesion, if the whole load was carried on a pair of steam bogies, as Mr. Fairlie proposes. The resistances being $\frac{1}{6}$, and the pressure on the rails $\frac{11}{12}$ of the total weight, the resistances will be equal to $\frac{1}{11}$ (for a very slight fraction over $\frac{1}{12}$) of the actual pressure upon the rails. So long, therefore, as the coefficient of friction between the wheels and rails exceeds $\frac{1}{11}$ th, the combined engine and carriage will have sufficient adhesion to take itself up the incline without it being necessary to increase this adhesion by the use of mid-rails, gripping wheels, or any such complex expedients. Now $\frac{1}{11}$ th is a very low coefficient; under ordinary circumstances, the adhesion of locomotive driving wheels averages probably about $\frac{1}{10}$ th of the load upon them, and it is occasionally much greater. Even on mountain lines, exposed to snow and sleet, we see no reason why the coefficient should ever fall below $\frac{1}{10}$ th or $\frac{1}{11}$ th, if the engines are provided with proper fittings for keeping the rails clean. To remove ice, snow-brooms followed by pipes delivering small jets of steam upon the rails might be employed, and these appliances, combined with the use of sand, would render it easy to at almost all times keep up the coefficient to quite the amount we have mentioned. The use of steam jets for clearing the line of snow was tried on the Caledonian line some years ago, and was, we believe, found to answer well. Under these circumstances, therefore, a combined engine and carriage on Mr. Fairlie's plan might, as far as adhesion is concerned, easily be worked up an incline of 1 in 12 in all weathers, and under all ordinary circumstances it would probably ascend a gradient considerably steeper.

So far, in dealing with Mr. Fairlie's plan, we have only considered the question of adhesion; but there are two other points to be looked to, these being the provision of sufficient cylinder power, and of sufficient boiler power to supply the cylinders with steam. First, as to cylinder power, the engine illustrated on page 342 has, as we have already stated, four cylinders, each 11 in. in diameter, with 16 in. stroke, and wheels 2 ft. 8 in. in diameter. With an average effective pressure of 90 lb. per square inch on the pistons (a pressure which could be readily obtained with steam at, say, 140 lb. in the boiler), the tractive force the engine would be capable of exerting would be equal to

$$\frac{121 \times 2 \times 16 \times 90}{32} = 10,890 \text{ lb.}$$

On an incline of 1 in 12 the resistance due to gravity would be 186.66, or, say, 187 lb. per ton, and if to this we add 20 lb. for frictional and other resistances, we shall have a total resistance of 207 lb. per ton. And 10,890 divided by 207 gives 52.12 tons as the load which the cylinder power of the engine would enable it to take up the incline just mentioned. Mr. Fairlie, however, intends that the engine should weigh considerably less than 52 tons, or, say, 42 tons, this weight giving a load of $3\frac{1}{2}$ tons per wheel. The total weight would, however, be to some extent dependent upon the amount of boiler power provided, and this boiler power would, in its turn, have to be regulated by the speed at which the engine was to be run. This question of boiler power we will now proceed to consider.

Of the total weight of the combined engine and carriage, that portion due to the fuel, water, and load would be about as follows:

	tons.
68 passengers, say	4
400 cubic feet of luggage	10
1000 gallons of water	$4\frac{1}{2}$
Fuel	$1\frac{1}{2}$
	20

Supposing the total weight to be 42 tons, there would thus be 22 tons of this weight available for the frames, wheels, passenger and goods compartments, and boiler, and, with care in the designing, this weight would no doubt be found sufficient. In fact, Mr. Fairlie considers that the weight of the engine empty, need not exceed 20 tons, and, judging from the working of the Mont Cenis engines, it seems certain that within this latter weight ample boiler power can be provided to work up the whole of the adhesion.

Before concluding our notice of Mr. Fairlie's engine, it will be as well that we should compare it with those constructed on Mr. Fell's principle for the Mont Cenis. The highly objectionable complexity of these latter engines has already been pointed out in this journal, and we shall therefore not say more about it here, but shall merely consider them as machines that have been proved by experiment to have certain hauling power. The second engine made for the Mont Cenis took over the experimental line, during Mr. Brunlees's visit in 1865, a load of 24 tons, exclusive of its own weight, at the average rate of 6.8 miles per hour, and a load of 16 tons at the rate of 9.6 miles per hour, the steam pressure in each case rising during the trip. The experimental line was about $1\frac{1}{2}$ miles long, and it had an average gradient of 1 in 13, and a maximum gradient of 1 in 12. The engine weighed about 17 $\frac{1}{2}$ tons, and there was during the experiments a pressure of about 10 tons on the horizontal wheels, making the total weight available for adhesion 37 $\frac{1}{2}$ tons. This weight of 37 $\frac{1}{2}$ tons gave sufficient adhesion to enable the engine to take up a total load of $17\frac{1}{2} + 24 = 41\frac{1}{2}$ tons, and, judging from this, Mr. Fairlie's engine with 42 tons of adhesion weight would take up a load of

$$\frac{42 \times 41\frac{1}{2}}{37\frac{1}{2}} = 46.48,$$

or say 46 $\frac{1}{2}$ tons. The main point shown by this is that, under the circumstances of the Mont Cenis trial, Mr. Fairlie's engine would undoubtedly have sufficient adhesion to take more than its own weight up an incline of 1 in 12; and as it has sufficient cylinder power to take a load of over 52 tons up this incline, there is no reason why it should not, when used for goods traffic, be made to carry that load. In comparing Mr. Fairlie's and the Mont Cenis engines, it must not be forgotten that the 24 tons taken up by the latter included the weight of the carriages and trucks, whereas in the case of Mr

Fairlie's engine, loaded up to 52 tons, there would be at least 24 tons of *paying* load. When loaded to 52 tons, the weight per wheel of Mr. Fairlie's engine would be about the same as that of the Mont Cenis engine. We may here say a few words about the boiler power of the Mont Cenis engine. The total weight of the second engine is, as we have said, 17 $\frac{1}{2}$ tons, and its net weight is 13 tons, of which about 2 tons 13 cwt. are due to the horizontal wheels and their gearing. The actual weight of the boiler frames, vertical wheels, and gear, &c., is under 10 $\frac{1}{2}$ tons, and yet the boiler has, by experiments, been proved capable of supplying sufficient steam to work a load of 41 $\frac{1}{2}$ tons up 1 in 12 at a speed of 6.8 miles per hour. Under these circumstances Mr. Fairlie cannot be wrong in estimating that the framing, boiler, &c., of his engine can be constructed so as to weigh not more than 20 or, at the most, 22 tons.

The engine illustrated this week is, as we stated at the commencement of this notice, one designed by Mr. Fairlie some years ago. Mr. Fairlie has, however, recently got out some other—and we think improved—plans for engines of this class, and these we hope to illustrate in an early number. In his more recent engines—which, like that now illustrated, are carried on two six-wheeled steam bogies—he employs a boiler with one barrel only, and on each side of this barrel he forms compartments for goods. The boiler only reaches to the middle of the length of the engine, and behind it is the compartment for passengers. Mr. Fairlie proposes that this engine should have a total weight, when loaded, about equal to that of the present Mont Cenis engines *plus* the pressure which the horizontal wheels of these engines are capable of exerting against the mid rail, a pressure equal to, say, 24 tons as a maximum. He will thus have the same weight for adhesion as those engines, and as the weight of his boiler and two steam bogies need not greatly exceed that of the boilers of the Mont Cenis engines with their vertical and horizontal wheels and complex gear, there will be a large margin left for paying freight and the weight of the compartments in which it is carried. We shall, however, have more to say about Mr. Fairlie's new plans when we illustrate them; at present we need only say that they are well worthy of the attention of all engineers connected with mountain railways.

LEIGH'S LOOSE BOSS ROLLERS FOR SPINNING MACHINERY.

The annual loss sustained by cotton-spinners who persist in using the common top-rollers is incalculable, as every machine containing them is continually spoiling its work from their running faster when fresh oiled, and slower when they get dry. The friction upon the common roller, always excessive, is greatly increased as the oil is dried up, which is soon the case from the exposure of its bearings to fluke and dust when it ceases to give out the length of silver or yarn intended, causing continual irregularities. Another cause of mischief arises from the impossibility of covering the bosses so as to be of exactly the same diameter; then there is a continual contention for speed going on, which abrades the leather, puts great torsion on the under rollers, consumes power, and causes licking and flat waste. It is attempted to obviate the latter, in vain, by varnish and pastes, which only harden and take the elasticity out of the leather covering. This, together with the oil and filth with which both leather and cloth get saturated, causes rapid destruction, necessitating three times the roller covering that would otherwise be required. Another defect is the wearing of cap ribs, saddles, and hooks, the former throwing the rollers out of parallel, the latter binding them when worn concave. Leigh's loose boss roller is a complete remedy for all these defects. They require oiling only once a month at most, and will run three months or more if good sperm oil be used, one gallon of which is sufficient to serve all the rollers in a large mill for twelve months, if used properly, when no oil-stain will be seen on any roller. In England the practice has been generally to apply them only to the front row (with a few exceptions), but in America, Russia, and India a much larger proportion of spinners employ these rollers in both back, middle, and front rows. The following American firms have gone entirely through all the rows, viz.:

	Spindles.
The Androsscoggin Mills, Lewiston, Maine	84,000
" Hill Mills Co.	60,000
" Bates Mills	30,000
" Pepperell Mills, Biddeford, Maine	75,000
" Salmon Falls Co., New Hampshire	30,000
" Boot Mills Co., Lowell	57,000
" Union Manufacturing Co., Baltimore	20,000
" Jackson Co., Nashua, New Hampshire	20,000
" Merrimac Co., Lowell	90,000

Besides the above, many others are under contract to go entirely through all the rows of their rollers with the loose boss.

THE SUZ CANAL.—The Suez Canal Company charges itself now with the conveyance of goods from the Mediterranean to the Red Sea, and reciprocally. This provisional working is carried on partly by the maritime canal and partly by the sweet-water canal, and the English Government is availing itself of the facilities offered by forwarding by the new route horses, forage, and other stores required in connexion with the Abyssinian expedition. The French Minister of Marine has also on several occasions availed himself of the new route in the despatch of stores for Cochinchina. Everything forwarded has, however, to be transhipped, *en route*, from the sweet-water canal to the maritime canal.

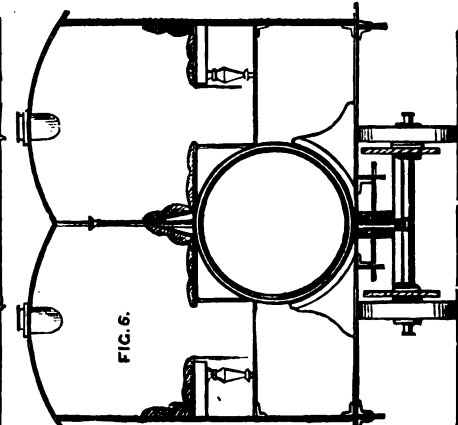
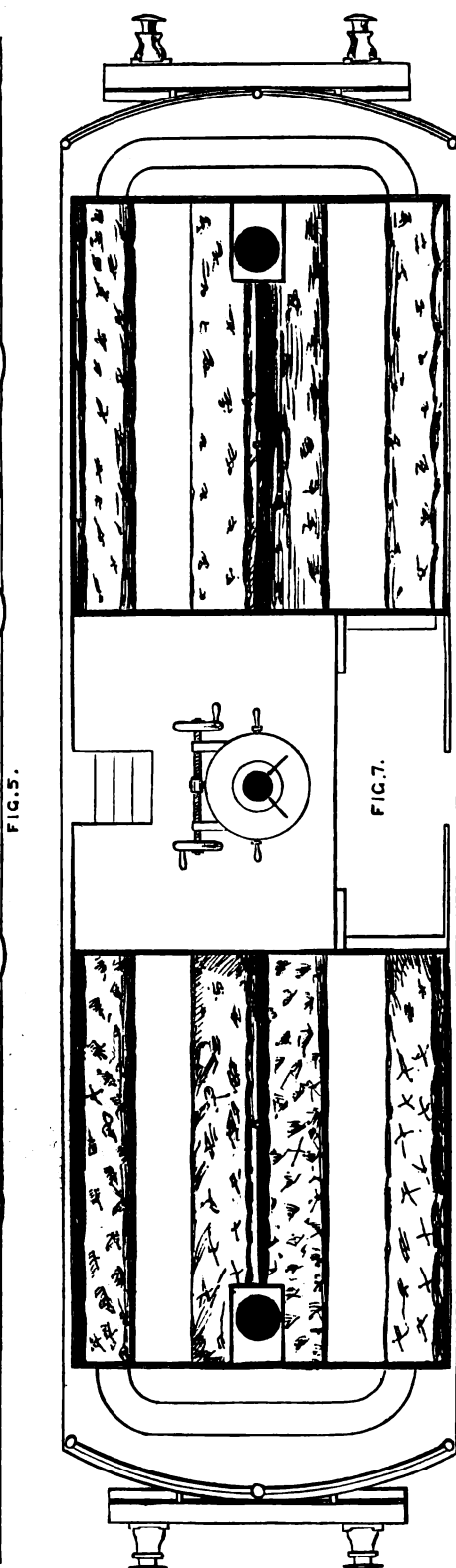
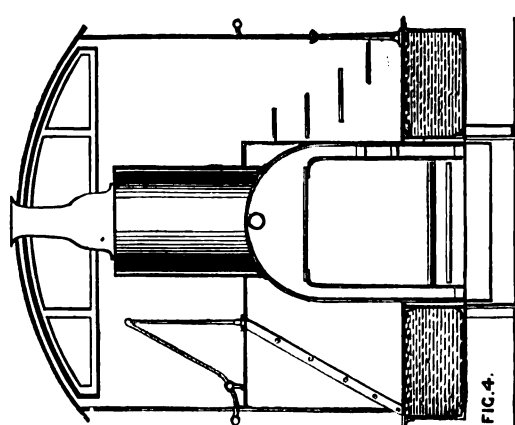
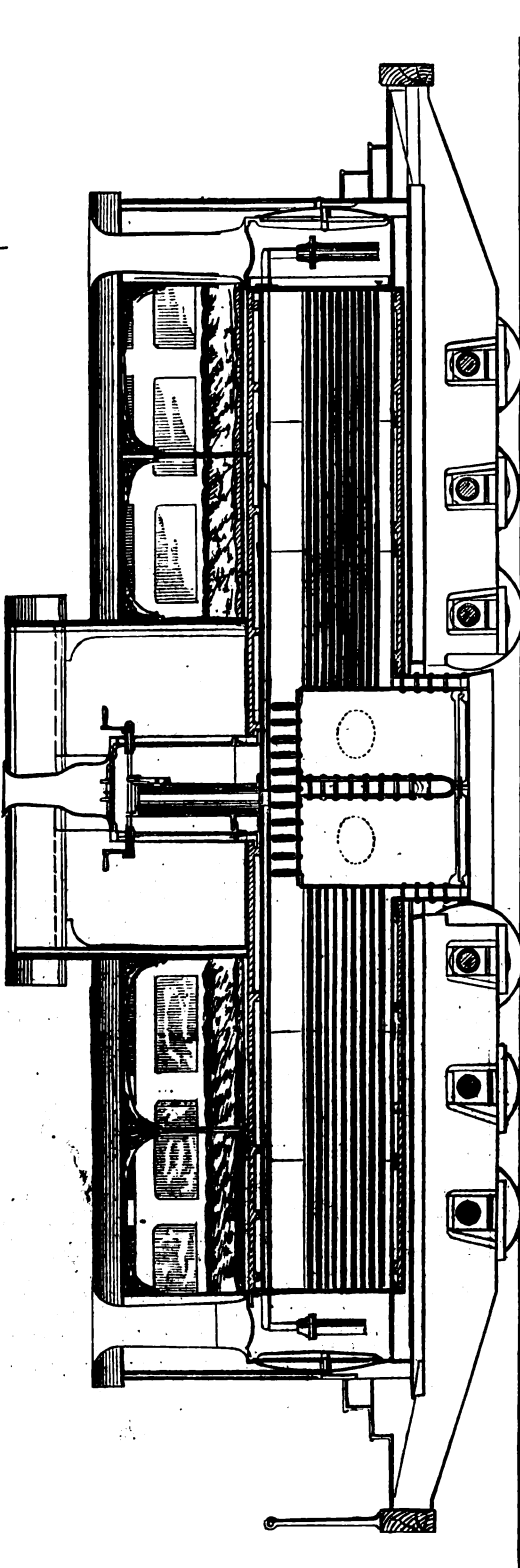
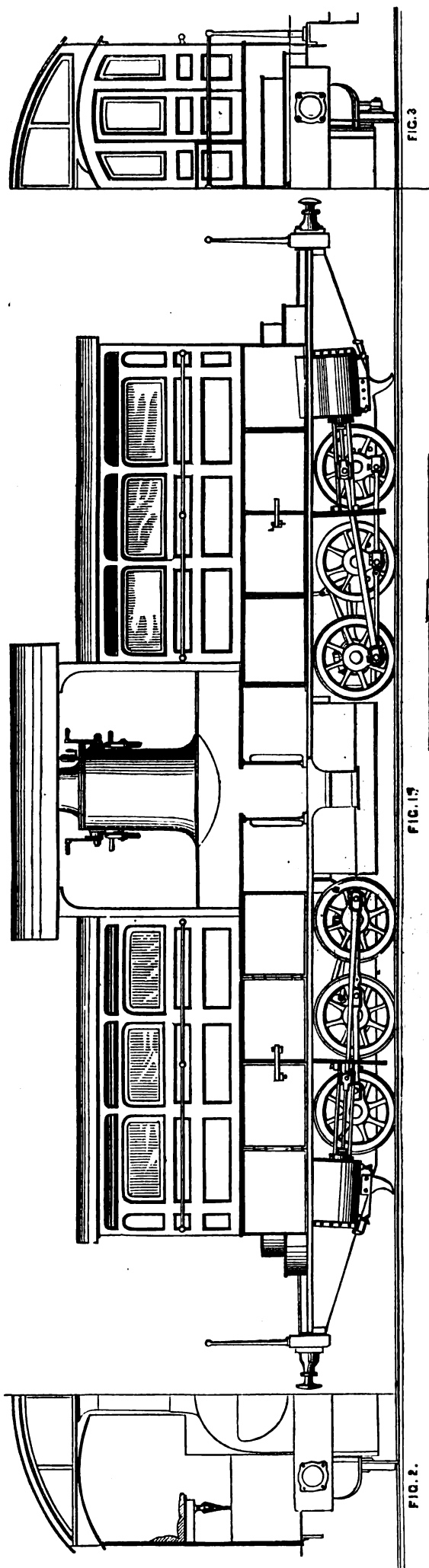
THE CLEVELAND IRON TRADE.—The demand for pig iron continues pretty good. The stock in store at Middleboro' is 70,497 tons. Autumn deliveries for the Baltic and Russian ports are drawing to a close. An order for railway chairs for New South Wales is stated to have been obtained. The shipments of Cleveland pig iron to the Continent to August 31 this year were computed at 99,717 tons, as compared with 65,299 tons to the corresponding date of 1866. The plate and merchant bar-iron trade is inanimate, but rails are in tolerable demand. Large deliveries of railway *matériel* continue to be made to Cronstadt and Riga for Russian lines in course of construction.

FROM THE NORTH.—Messrs. C. Mitchell and Co., of Low Walker, are fitting out a screw steamer of 1900 tons, as well as another of 1180 tons. Messrs. Palmer and Co. (Limited), of Jarrow, are also fitting out a screw of 730 tons. Messrs. Leslie have on hand a screw of 1160 tons. Seven tugs are also now being built on the Tyne.

LOCOMOTIVE CARRIAGE FOR MOUNTAIN RAILWAYS.

DESIGNED BY MR. ROBERT F. FAIRLIE, C.E.

(For Description, see the preceding Page.)





Sam. H. Hoebliug.

PARIS EXHIBITION.

WE publish, on this and the following pages, the jurors' reports on some of the classes of the Paris Exhibition. These reports were published, at the instance of the Council, in the *Illustrated London News*, from which journal we reprint them. Nearly all the works and machines mentioned in these reports have been already described, and many of them illustrated, in these pages:

APPARATUS AND PROCESSES OF THE ART OF MINING AND OF METALLURGY.

CLASS 47.

BY WARINGTON W. SMYTH, M.A., F.R.S.

THE peculiar subdivision and classification of subjects adopted by the French Imperial Commission have introduced into the work of the juries of 1867 sundry anomalies which would have been avoided by a less transcendental system. At our own Exhibitions of 1851 and 1862, the apparatus and the products of the arts of mining and metallurgy were conveniently classed together; whilst on the present occasion the miner and metallurgist found his raw materials and his products (in class 40) entirely cut off from the processes and implements by which he is accustomed to work them, and the two divisions severally grouped with other classes, which, in the real conduct of his business, have no connexion whatever with his own pursuits. This inconvenience could only be partially remedied by arrangements made by the secretaries of juries to pass certain of the objects exhibited from one class to another. In this manner the geological maps and sections, which ought to be regarded as the records of the exploratory labour upon which the work of the miner is to be based, were placed, in the building and by the catalogue, in class 13, along with ordinary geographical maps, but were claimed for consideration by class 40; whilst those which were on a scale detailed enough for being applied directly to the purposes of mining were taken up, along with models of mining localities, into the department of class 47. Similarly, it was agreed between the secretaries that the refractory substances, including plumbago or graphite crucibles, firebricks, &c., several groups of which had been exhibited in our class, should be transferred for the consideration of the jury which dealt with materials of construction in general, and which already had ranged under its numbers a long list of exhibitors of bricks, terra-cotta, and refractory materials.

In what belonged properly to class 47 the English portion of the Exhibition was exceedingly meagre; and neither alone, nor taken in conjunction with the display in class 40 (minerals and metals), could it pretend, in the remotest degree, to represent the greatness and the activity of mining and metallurgical life in the United Kingdom. The causes of this deficiency will readily suggest themselves to the minds of those who know our English works, and need, I think, no examination or discussion in these pages. But it is of the highest importance that, whilst our own producers decline so generally, from one cause or another, to enter the lists, we should inquire whether they can properly repose at a distance in fancied security, enwrapped in an atmosphere of self-satisfied superiority, or whether they ought not to be on the *qui vive* and preparing for fresh efforts, on seeing the examples which appear to mark an extraordinary degree of advancement on the part of our foreign competitors.

I propose, therefore, to invite attention chiefly to those objects which are likely to excite the interest of our own masters, overlookers, and workmen, in comparing what we know at home with that which is doing on the Continent.

Models and Plans of Mining Localities.

Some of the most remarkable works of this class are those which illustrate the complicated structure of that important coal-field which extends from the Belgian frontier through the Department du Nord and far into the Pas de Calais. The French Ministry of Public Works has exhibited a map (on a scale of 1 to 25,000) constructed by M. Dormoy, with sections attached to it taken across the breadth of the trough, and showing the position and thickness of the troublesome overlying bed of watery ground called the *torrent*. The map of the Pas de Calais, drawn by M. Cointe, is perhaps still more noticeable, as showing, on a larger scale (1 to 10,000), the energy and system with which, by means of an elaborate series of borings, all of them accurately recorded, the development of a valuable new coal-field has been accomplished within a very few years. It was only in 1846 that a boring for water at Oignies, not far from Douai, gave evidence of the continuation of the coal measures beneath the cretaceous strata in this direction. The borings of the Escarpelle Company proved, as was pointed out by M. Du Souiche, that the coal formation was sharply deflected north-westward from its old direction at Valenciennes; and hence arose, between 1850 and 1864, the establishment of nineteen new concessions, seventeen of which are in the Pas de Calais, and extend within that department over a length of about 35 miles. Some forty pits have already been sunk, having, on an average, 100 to 150 metres of overlying formations to pierce, and down to depths of from 180 to 300 metres for their workings.* The amount annually produced from this new and unseen district of coal has increased steadily from less than 5000 tons in 1851 to upwards of 1,600,000 tons in 1866.

* One pit—that of Ferfay—has its workings at the depth of 460 metres.

Plans of a most accurate character, on the scale of 1 to 5000, have been prepared from the elaborate surveys of M. Gruner to represent the conditions of the still more valuable but old-established coal-field of the Loire, generally known by the name of its chief town, St. Etienne; and a beautiful model, founded upon the maps of the same engineer, has been constructed by M. Leseure to exhibit the singular curves of the great seam of Rive-de-Gier, in the same district. This so-called *grande masse*, varying from 26 ft. to above 50 ft. in thickness, has been so far explored as to enable all its folds and faults and other accidents to be shown with great minuteness, the small portions which are still uncertain being left blank.

The works thus emanating from the Ministry teach us a useful lesson in connexion with the commercial history of France. Not even the rich and advantageously situated beds of Rive-de-Gier could be worked with profit so long as insufficient capital and a low state of technical knowledge prevailed. The hampering of the coal-miners with the claims of surface owners, the undue subdivision of the ground, and the inattention of the Government to the treatment of what was truly a large question, had, between 1832 and 1838, brought the district to the verge of ruin. Most of the collieries were losing money, numbers of them were being successively drowned out, and the prospects of the future were miserably neglected. The present large annual production of over three millions of tons from the basin of the Loire, and the clear light which is now thrown upon the natural conditions of the district, testify to the new life introduced within the last seventeen years by an improved organisation.

Another representation of the surprising progress made by France within a single generation is exhibited by the mining company of the Grand Combe (6, 19, and 31, France). Few, perhaps, of our countrymen who throng in numbers to Nîmes and Avignon are aware that, in those wild and storm-ravaged hills above Alais, the perseverance of the "industriels" has opened out a coal-field which promises to be a most important treasure to the south of France, and is already third on the list of the French coal-districts for its amount of production.* The ravine of the Grand Combe is the locality of the most active mining operations; and a very large model, showing all the plications and disturbances to which the basin of coal has been subjected, proves, at the same time, the great amount of exploration done within a few years, and the care with which all ascertained data are recorded. Plans, sections, and books of statistics, beautifully kept, are added for the further elucidation of the subject; and one point of especial interest to some of our English coal-workers will be found in the extension, in several places, of the coal-workings far beneath the overlying strata of the Trias.

Several other special localities have been admirably illustrated in the same manner, as the curious seam of coal worked at Creusot (Saône-et-Loire), the mines of the Commentry Company, and the iron-mines of Rancié. But, among them all, none are more worthy of observation than the plans of part of the coal-basin of Liège, executed by M. van Scherpenzeel Thim. By means of exact vertical sections which he has constructed for that field, to the number of 700, he has laid down the precise position of all the seams throughout a slice of the coal-field of 50 metres deep, selected between the horizons of 140 and 190 metres below the level of the sea, as being that portion of the basin which is of the highest present importance in laying out the practical operations. Between these two horizontal planes he determines the position of each bed at every 10 metres of depth; and, by a shading upon a system of conventional perspective, he has given a graphic representation, which, aiding the lines mathematically determined, presents to the eye a distinct picture of the underground relations of this highly contorted but valuable region.

These various labours testify to the close exactness of work and to the intelligence of the French and Belgian engineers, as well as to the careful spirit of their respective Governments in dealing with so important an element of national prosperity. How much would the labours of our recently appointed Royal Commission of Inquiry on Coal have been lightened and rendered satisfactory had similar documents been available in our own coal-fields, and had a similar precaution been exercised in registering the results of sinkings and borings, which upon our careless want of system are so often totally lost?

The excellent plans and sections in which the Prussians have recorded their important explorations of Westphalia and Silesia come rather under the head of geological maps, and were reported on at the Exhibition of 1862; but they are not the less worthy of attention from visitors who desire to understand the rapid development of the mineral wealth of these highly valuable districts of coal.

Working of Mines.

The laying out of the general plan of operations in coal-mines, and the methods adopted for the actual getting of the mineral, constitute a subject too extensive to be otherwise than partially illustrated in an exhibition. But, considering how such a subject involves the pecuniary economy of obtaining this mainspring of all modern industry, as well as the security of the hundreds of thousands of men who toil in what is necessarily a dangerous vocation, we may refer with advantage to a few contributions, which tell us somewhat of the processes used in France and Prussia.

* The yearly production of the coal-field of the Gard is now above 1,200,000 tons.

The days are quite past and gone when the coal-workings of these countries were petty and incomplete, and commonly feeble imitations of English originals. The great annual amounts now raised by them—12,000,000 tons by France, and 23,000,000 tons of coal and brown coal together by Prussia—suffice to show that an enormous trade has arisen, and that an experience has been gained both by directors and workmen, which has led to much independence of design and process. It has not been without difficulty that so considerable a development has been brought about within so few years, especially in the bringing up of a large population competent to deal with a new task; and in certain districts particularly, as in the department du Gard, the mining companies have had to take in hand all the details of social organisation, as if planting a colony in a desert land.

It may not be generally known that the coal-fields of Central and Southern France, although individually of small extent as compared with our own, are remarkable for the occurrence of seams of extraordinary thickness. The tolerably regular beds of coal at Blanzy and Montceau run to 50 ft. and even 60 ft. thick; that of Creusot, where it is raised up into a vertical position, varies from a few feet to 50 ft., 80 ft., and as much as 130 ft., measured right across; and the great seam of Decazeville (Aveyron) often extends to 100 ft. in thickness. Their very magnitude, to say nothing of their often distorted position, entails on the workers a variety of difficulties, which it has taken a great number of years successfully to surmount. One method after another has been tried, and many successive improvements have been introduced, chiefly tending to guard against crush and creep, alike destructive to the getting of coal of fair size, and dangerous to the life and limb of the workmen. At last, by common consent, it is allowed that the only full and satisfactory method of getting the largest quantity of coal and of ensuring safety to the men, is that of systematic "packing" or "stowing" of all their bords, stalls, or gobs—of all excavated places, in fact, except the needful roads—with rubbish (*remblais*) carried down from the surface for that purpose. A night shift of men, the *remblayeurs*, are occupied with this task whilst the colliers are absent from the mine; and in some districts a particular shaft and line of roads and special wagons or tubs are set apart for the work. I am glad to be able to bear witness, from inspection at Montceau and at St. Etienne, how methodically the complete packing is carried out, and how it forms a surprisingly good roof to work under when the next stage below it is attacked. It would be out of place here to enter into the details of the arrangements under which this process is securely followed; but the large block model of the Creusot collieries may be mentioned as showing very fully the curiously irregular position of one of these seams; and the model in the midst of the iron productions of Commentry as illustrating the means of working away the successive horizontal ranges of the thick coal-bed of that locality, by the aid of a close packing. A question of this kind can only be fairly judged by reference to the figures obtained from actual experience, which tell of its relative economy. A great expense is undoubtedly incurred; for we believe that, in some pits, as many as one-third of the men are engaged as *remblayeurs*. But it would appear that, considering the saving in timber, in round coal, and the comparative immunity from accidents, the French engineers have reason to be satisfied with a system which is the growth of many years of study and practical trial.

It is notorious that a chief reason of the inability of the French ironmasters to rival in cheapness their English competitors is the considerable higher price which they have to pay for coal. The reasons for this are manifold. Whether timber propping or stone packing is employed in the pits, it is necessarily in much larger proportion than in our more favourably-conditioned English and Welsh coal-seams. A French collier, as a general rule, can only get in a day's work from half to four-fifths of what an English hewer will break down. It is only in the pillar-working (*dépilage*) of the thick seams that the French workman obtains an advantage and can get as much as six or seven tons in the day; but for this task he needs a special skill and experience, and earns a much higher wage than the average.*

Owing, again, to the irregularity of the seams, a far larger comparative cost falls to the item of dead work; and for the same reason the underground transit remains generally on a very inferior footing to that of our first-rate British collieries. Moreover, the total number of people employed about a coal-pit in France has to be exceptionally large for a given out-put of mineral, in consequence of the general need for carefully cleaning or washing the coal. It is thus only marvellous that, considering how a numerous working population has had to be educated to a peculiar class of labour, the amount of coal raised in France has risen from 1,800,000 tons in 1830, to close upon 12,000,000 tons in 1865. The high civilisation of the country needs, however, a much larger amount, and the importations of 1865, chiefly from Belgium, amounted in coal and coke to about 7,100,000 tons besides.

Up to the advent of railways our neighbours across the Channel had, in fact, developed their coal-fields to a very trifling extent, and their knowledge of the practical art of mining stood at a low point; but since that period the general advancement of trade and manufacture has been

* The daily wages made by French colliers in the central coal-fields are from 3s. to 4s., according to the nature of their work.