

PROPOSED BRIDGE OVER THE HOOGHLY, AT CALCUTTA.

MR. THOMAS PAGE, ENGINEER.



THE proposed bridge, of which we annex a perspective view, is one designed by Mr. Thomas Page, in 1864, for erection across the Hooghly, at Calcutta. The bridge was intended to carry a line connecting the East-Indian Railway on the western with the Calcutta and South-Eastern on the eastern side of the river, thus enabling the East-Indian Railway traffic to be brought right into Calcutta itself, and also placing Port Canning, on the Moolah, in railway communication with the East-Indian Railway district. At the point where it is proposed to construct the bridge, the river is about 1800 ft. wide, and the bridge was to consist of four spans of 400 ft. each, besides a central draw-span of 80 ft. Each of the large spans was to consist of three bow-string girders placed 23 ft. 6 in. apart in the clear, one of the two lines of roadway being intended for the railway and the other for the ordinary road traffic. Two footways, each 8 ft. wide, were also to be carried, one on each side of the bridge, on cantilevers. The accommodation afforded by the bridge would, it was believed, have led to the formation of an extensive suburb to Calcutta on the opposite side of the river. Whether or not the bridge will ever be constructed we cannot say, but, in any case, the bold and artistic character of the design well merits a place in our pages.

NOTES FROM INDIA.

PETROLEUM wells at Luckimpoore, in Assam, are now being worked with partial success.

The population of the French possessions in India, comprising Pondicherry, Chandernagore, Karikal, Mahé, Yanam, and their districts is, according to the last census, 229,000 souls. The superficial extent is 49,000 hectares, or 122,500 acres.

A call of 15l. per share has been made on the shareholders of the Mazagon Land and Reclamation Company. The drainage of Bombay is still a matter of controversy, and the local Government says it can do no more towards providing the funds than guarantee a loan for the purpose. A petition has been got up in Bombay with a view to prevent the extension of the Bombay, Baroda, and Central India Railway along the Esplanade; but a counter-proposition had been prepared, and, in the mean time, the railway works along the Back Bay progress.

Owing to the inundations in Bengal, from Kooshtea, the Ganges terminus of the Eastern Bengal Railway, to within some forty-three miles of the capital, the whole country presents the appearance of a vast inland sea. Railway bridges

show unmistakable signs of distress, and embankments disappear bodily, rendering the running of through trains, if not an impossibility, at least a matter of great risk.

The sea continues to make considerable encroachments at Cochim. A new lighthouse has been building for some time, the two former ones having fallen down, and the sea is beginning to sap away its foundations before it is completed. At Vypeen a gap has been going on widening and deepening till the sea made a rush through and engulfed a great portion of the island. The harbour, too, which is one of the oldest and best in India, is in danger of being barred up.

A correspondent of the *Sindian*, writing from Mooltan on September 16, gives a very discouraging account of the state of steam navigation upon the Indus. The grounding of steamers, collisions, and delays protracting the passage to nearly double the usual time, are some of the many evils to which travellers by the Indus steamers are exposed, and which renders the construction of the Indus Valley Railway highly desirable. It is evident that no reliance could be placed upon the present system of transit by the Indus steamers, were it found necessary to send round from Bombay to Kurrachee a large body of troops in case of emergency;

for service in the Punjab. As to the improvement of the Indus river, an enormous outlay would be required to render the navigation of the Indus at all times secure; and it is very questionable whether, even at vast expense, such an object could be permanently attained, owing to the shifting condition of the channel of that river; so that, instead of wasting money upon vain efforts to control the sands of the Sindhi, it would be much better to undertake, without loss of time, the construction of the long-mooted Indus Valley Railway, which will connect Kurrachee and Kotee with Mooltan and Lahore, and ultimately form an important link of the great iron road destined to unite the Bay of Bengal with the Arabian Sea.

GAS IN PARIS.—The revenue of the Parisian Company for Lighting and Heating by Gas is still making rapid progress. The receipts of September were 96,459l., as compared with 88,626l. in September, 1866, showing an increase of 7888l., or 8.84 per cent. The total receipts to September 30, this year, were 873,826l., as compared with 788,144l. to the corresponding date of 1866, showing an increase of 85,682l., or 10.87 per cent.

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.

The price of ENGINEERING to annual subscribers, receiving stamped copies at places three miles away from the General Post Office, is 11. 1s. 8d. If credit be given, the charge is 2s. 6d. extra, subscriptions being payable in advance.

Cheques and money orders to be made payable only to Mr. Charles Gilbert.

Office for Publication and Advertisements, No. 87, Bedford-street, Strand, W.C.

ENGINEERING is registered for transmission abroad.

D. Van Nostrand, 192, Broadway, New York, is the sole American agent for ENGINEERING, and is authorised to receive all Subscriptions and Advertisements from America for this paper.

Le bureau d'ENGINEERING pour la France est 15 Quai Malaquais, Paris, chez E. Lacroix, Directeur des Annales du Génie Civil.

Subscriptions for the ANNALES DU GENIE CIVIL are received by Mr. Charles Gilbert, the Publisher of ENGINEERING, of whom also the NOUVEAU PORTEFEUILLE DE L'INGENIEUR DES CHEMINS DE FER may be obtained, price 91.

THE ST. HELIER HARBOUR COMPETITION.—In the engravings which we published last week of the various competitive plans for the improvement of the harbour of St. Helier, the names on Plans Nos. 7 and 8 were, by an error, transposed, that numbered 7 being really the one proposed by Mr. Coode, and No. 8 that by Messrs. Brooks and Murray. Messrs. Brooks and Murray's estimate for the whole of the works proposed by them, including the dock and 10 per cent. for contingencies, amounts to 364,034*l.* We may add that, in the article on the St. Helier harbour, on page 416 of our last number, the engravings were, by an error, said to be drawn to scale, whereas it should have been stated that they were but sketches intended to show the main features of the proposed plans.

MEETINGS NEXT WEEK.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 12, at 8 P.M. Discussion upon Mr. Byrne's paper, "Experiments on the Removal of Organic and Inorganic Substances in Water."

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.—Wednesday evening, November 13th, at 8 o'clock. "On Armour-clad Ships of War," by Mr. Frederic H. Roberts.

ENGINEERING.

FRIDAY, NOVEMBER 8, 1867.

THE ABYSSINIAN RAILWAY.

It appears from the Indian advices that a quantity of railway material has been landed at Massowah, the commander of the Abyssinian expedition having decided to remove his base inland. We believe that the question has been under consideration of constructing a surface line far inland, towards Debra Tabor, and perhaps within fifty miles of that point, or, say, two hundred miles from the Red Sea. We will not ourselves estimate the cost of taking out and laying down 20,000 tons of railway material in a country practically unknown, but there are those whose opinions are entitled to much confidence who maintain that it might be done for a million of money, and that, even at this cost, and placing the most moderate money value upon a soldier, the saving of life on our side, and the efficiency of the attack, would more than compensate for it. 35 lb. steel rails and Greaves's or Griffin's iron sleepers could be laid very rapidly along a surface line. We publish, on another page, an account of the laying of the line of the Pacific Railway, over the vast plains of Western America, at the continuous rate of two miles a day. It may be said that labour requisite for such work could not be supplied in Abyssinia, and that, even could two miles a day be put down, more than three months would be spent in getting two hundred miles inland, a period within which the captives whom we seek might die, or King Theodore complete increased means of defence, to say nothing of constantly harassing our working parties.

The value of military railways is, however, incalculable. They give to the general a base near or close to the scene of operations, and this is, beyond all question, one of the first elements of military success in an enemy's country. But for the railways whereby Sherman brought his troops to Atlanta, he could never have made his famous march of 300 miles through Georgia, and thus thrown himself upon Lee's rear.

One difficulty in the case of Abyssinia is that of the steepness of some of the mountain passes. It has been suggested that these might be overcome by Mr.

Fell's engine, but this has not succeeded well upon the Mont Cenis, and its use would require at least 30 tons more rails, and a large additional quantity of other material, over every mile upon which it was laid, besides increasing the time required for constructing the line. Engines carrying their load upon their own frames, and having steam bogies under each end, would ascend any incline less steep than 1 in 8, and the railway might be pushed at least to as far as gradients of no greater inclination could be secured.

The war may prove longer and more costly than has yet been anticipated, and an Abyssinian railway, now hardly more than a suggestion, beyond the short length to be laid inland from Massowah, may yet become a military necessity.

STEEL RAILS.

ON another page will be found a letter, giving an ironmaster's view of the question of steel v. iron rails. Those, however, who consider the further renewal of heavy-traffic lines with iron rails as incompatible with true economy will hardly find their convictions shaken by our correspondent's letter. When we say that iron is cheaper, ton for ton, than steel, we have admitted all that it is possible to say in its favour as a material for railway bars. It is neither so durable, so strong, so stiff, nor so tough as steel, and it is not possible, therefore, that a line laid in iron can bear as heavy loads, and at the same time preserve as good a working surface, or the great truth and smoothness essential to easy traction, as one laid in steel of the same weight. That steel outwears many times its weight of iron—in at least one case twenty-five times its own weight of iron—has long since been established beyond all dispute. That the steel rail, when worn too far for further service, is at once convertible into excellent steel goods of other descriptions is also well known. That the steel rail which is sufficiently hard to wear out many times its weight of iron will, when laid upon 3 ft. supports, withstand repeated blows of a one-ton ram, falling from 20 ft. to 30 ft., may be seen any day in Sheffield, in Manchester, in Bolton, at Barrow, and at Dowlais, or wherever else any one may care to fit up apparatus and make the experiment. That the deflection of the steel rail, under a given weight, is much less than that of iron, and that its elastic limit is much higher, is too well known to need any statement, and it is thus clear that, once straight, a steel rail will remain straight under a load with which an iron rail would break down; in other words, a line which shall remain smooth and straight, except where purposely curved, may be secured in steel where iron of the same weight per yard would fail. Indeed, even the old fish-bellied rails, which would never stand, might now be made in steel and to do very well.

The Bessemer process has enabled us to produce steel at far less than its former cost, but not so cheap, ton for ton, as iron. Railway companies still demur, therefore, at paying 12*l.* or 14*l.* a ton for steel when they can obtain iron at from 6*l.* to 8*l.*, but mainly because more ready money is required, and not, probably, from any real doubt of the advantages of steel. They might, however, employ steel rails, which, while of much lighter section, would still have a strength equal to or greater than that of iron, and which should yet have a very far greater durability; and in this way a mile of steel line would cost but little more than a mile of iron line. This would, indeed, appear to be the rational manner of substituting steel in place of iron, just as we make a girder of less section in wrought than in cast iron, because the proportions essential with the latter material would be needlessly strong with the former, and just as those ship-builders, boiler-makers, and bridge-builders who have already used steel plates adopt a thickness for them at least one-third less than that for iron for the same purposes.

We do not recommend, however, that steel rails of light section should be put down in the place of heavy iron rails, inasmuch as our traffic and, notably, our engine weights are increasing; and in putting down rails which are to last twenty years, where iron would not last perhaps more than five, this steady growth should not be lost sight of. Another point of much importance is that the steel rail of full section has a much greater strength than the iron rail, and thus preserves a much better working surface; and the truth and smoothness of the working surface of the rail is the one test of the excellence of the railway, and upon it depends the whole question of working expenses. To the minds of ironmasters a somewhat uneven and slightly yielding rail no doubt appears good enough "for all practical purposes," just as chipped

and filed surfaces and rust joints were once thought good enough for steam-engines. And the difference of deflection, under a 5 ton driving-wheel, of a steel and an iron rail would no doubt appear to such minds infinitesimal, since anything necessarily measurable in hundredths and thousandths of an inch is naturally infinitesimal to them, although to an engineer, to say nothing of men like Mr. Whitworth, a hundredth part is a comparatively coarse subdivision of the inch. Just so the difference of deflection between even a 45 lb. and a 75 lb. iron rail would appear infinitesimal to the ironmaster and mill-manager, although a line like the Great Northern, which is worked very well on the heavier rail, could not get on for twenty-four hours with the lighter one, nor could its splendid running order be well maintained with 60 lb. rails. Could railway engineers, generally, form a nice appreciation of the inequalities, which hard-handed practical men regard as infinitesimal, in the working surfaces of our railways, and could they understand that it is almost wholly to these that the fact that a very considerable portion of the resistances increases as the square of the velocity is due, they would have no other than the stiffest and truest rails, and these, it is needless to say, can be better obtained in steel than in iron. More, probably, than one shilling per train mile of the present working expenses of railways is directly due to the want of perfect truth and smoothness in the rails. As our correspondent observes, brittle steel rails have been made, and, by careless men, may be made again, just as iron rails often are. Thus, iron rails have been known to break in three pieces, merely on dropping on the ground when unloaded from a wagon. If the punch is found to injuriously affect steel rails, the holes for the fish-bolts may be drilled quickly and cheaply with tools made of Vickers's special steel; and as for the rest, it is too much to say that the rail which, when laid on 3 ft. bearings, withstands, as we have often seen it withstand, the fall of a 1 ton ram from a height of 30 ft., without breaking, is brittle.

Our correspondent, as a practical ironmaster, perceives that steel rails must advance in price, even when the Bessemer royalty is lessened or removed. We know of recent offers of Bessemer rails, delivered free on board, for 11*l.* 10*s.* a ton! And we fear they will not be as low again any time within the next three or four years. So far as is now known, it is hardly possible that they can be. Our correspondent, too, owns that iron rails, in order to compete with steel, must be made at increased cost, and sold at an increased price. This is quite an ironmaster's view, and it happens to be one in which we fully concur.

As a makeshift, our correspondent proposes steel-headed rails, which may be compared to girders with wrought-iron flanges and cast-iron webs, although even this does not do justice to the latter, for the flanges of a rail girder are its head and its base, and these our correspondent proposes to make, in a great measure, of an inferior material—iron instead of steel.

There is no doubt that, if a good weld could be obtained between iron and steel, when the compound bar was to be exposed to the severe usage of railway traffic, the durability of the rail as measured by mere surface-wear would be increased. But no really satisfactory steel and iron rails have yet been produced. Specimens have been made which have borne severe tests under a steam hammer or a hydraulic press, but the continued vibration due to traffic separates the iron from the steel. We have the very highest authority for this, although we are not at liberty to quote it with the name of our informant, concerning steel-and-iron rails, which, a few years ago, were believed to promise excellent results, and which were extensively adopted on one of the most important railways in the kingdom. Besides, even if such rails were sound or perfectly homogeneous, they would not have more than two-thirds the strength of a rail made wholly of steel. It is the superior strength of steel, whereby it preserves a truer wearing surface, that constitutes one of its greatest advantages. It is more than likely, too, that steel-headed rails would be unworkable, and therefore, valueless when worn out.

WATERWAY FOR BRIDGES.

THE fall of a bridge is, unfortunately, no uncommon occurrence in India, and, although we do not now hear of such disasters happening quite so often as was the case in former years, yet, in the event of any unusually high floods, such as occurred during the monsoon of the present year, some bridges are sure to go. This may be accounted for in two ways: first, as we have lately shown was the case with the Great Indian Peninsula Railway bridges, by reason of defective construction; and, secondly, owing to the want of insufficient waterway. In a recent article on the forests

of India, and the effect caused by their destruction on the waterfall of the country (*vide* ENGINEERING, for the 25th of October last, page 400), we pointed out how, especially near the foot of the hills, many rivers in India have of late been subject to more severe floods than were known in former years; consequently, greater waterway must be provided in bridges over rivers subject to such fluctuations in the volume of water passing down their channels than may have been formerly considered necessary. All the rivers of India may be said to be more or less influenced by such changes, and too great care cannot, therefore, be exercised in designing bridges for them. It is not enough, as has been too often practically demonstrated, to take the highest known flood as the standard upon which the necessary waterway should be calculated; but provision must be made for higher floods still, and the extra expense that must be incurred on this account will prove an economical expenditure in the long run, if, by saving the life of the bridge, it prevents the necessity for its speedy reconstruction. Important as this is for bridges on ordinary lines of communication, it is doubly so for railways, since the traffic on them is so much greater, and the means of even temporarily passing it across a river are less easy of attainment than they would be in the case of the general class of ordinary road traffic. The following measures have been suggested for the case of railways in India as a probable remedy for all, excepting the most extraordinary, floods. It is proposed, then, that a line of levels should be run parallel to the existing railways, and at a distance of about one or two thousand feet from them on their up-stream side, and that cross sections be taken from it to the line of railway at each dip in the land, and particular inquiries made from the neighbouring villagers as to whether at any time within their memories water has lodged there or run off from there in the direction of the line of railway, and also let them point out the width, from which, of course, the depth could easily be ascertained. By this means an accurate knowledge of the fall of the land towards the line of railway would be obtained, as well as the probable quantity of water running in that direction, enabling the engineers to fix upon a proper width for their flood openings. It would be quite sufficient if a "check line" were run by the most convenient route, avoiding any interference with private property as much as possible. The present assistant engineers, it is thought, would be quite sufficient for the work, and but slight extra expense (in the shape of tentage) need be incurred. The cold season is soon coming on, and they could easily be spared for about ten days out of the month without detriment to their other pursuits, and, as two trips would suffice, they could not well complain of any hardship in the case.

Whatever merits the above remarks may possess, we contend that it should not be necessary to incur all such additional labour and expense, after the completion of a railway, in order to provide against ordinary floods. It is undoubtedly the fault of the engineer if he has not taken the means to inform himself on this point before perfecting his designs. It is, however, with reference to the necessities occasioned by extreme and, perhaps, unprecedented floods that more consideration should now be given, and provision be made so much in excess of actual known requirements, whereas the great mistake hitherto appears to have been in trying to narrow the waterways. This should never be attempted, says the *Delhi Gazette*, and the Government engineer ought not to allow such a proceeding, or results similar to the late accident at the Sae, on the Lucknow and Cawnpore line, will always happen. Had 30 ft. openings, instead of 20 ft., been adopted, it would never have occurred. Far better and safer, and cheaper in the end, to have too much waterway than too little. For such errors the contractors are blamed by the public, whereas they are entirely caused by the carelessness of the engineers of the railway companies in getting out their plans and sections, and not sufficiently well examining the country, and in putting in the minimum number of openings, in order to make each one his own piece of work appear the cheapest, and consequently to the best advantage, and apparently ignoring all consequences that an embankment may have on the usual drainage channels of the country.

STEEL-MELTING CRUCIBLES.

THE problem of finding a suitable material for making steel-melting pots is one which has long occupied the attention of metallurgists, and—as it appears from the differences of opinion and of practice existing at this present time—the search after such a material has been attended with partial success only. We have

recently recorded the practice of some eminent Sheffield steel-makers who, from preconceived notions, and probably from some former experience in that district, consider fire-clay to be the only suitable material for steel-melting crucibles. We have also published a very interesting statement of one of our American correspondents with regard to the influence of plumbago upon the quality of steel. There are some other facts worth recording in respect to this important subject. The crucibles used in the works of M. Krupp, in Essen, for melting steel, and particularly for the very softest kinds of this material, are all made of plumbago. A cheap supply of this plumbago is one of the principal cares of the managers of the Essen Works. The crucibles are made on the spot, and each crucible is used for one charge only, after which the material is disintegrated and used again for making melting-pots, for which purpose it is mixed with a certain proportion of fresh graphite. When large steel castings are made, a special subterranean receptacle is provided for these empty crucibles, which, in the case of a casting like the 40-ton ingot exhibited in Paris, would form such an enormous heap of heated materials, that the accumulation of crucibles in the vicinity of the casting-pit while teeming a large ingot would make the work almost impracticable. With the existing arrangement, however, each melting-pot disappears below ground the instant that it has discharged its contents into the mould. The influence of the graphite crucible upon the quality of the steel melted in it is generally overrated. There can be no doubt that the graphite is to a certain extent taken up by the steel, and therefore the tendency of a graphite crucible is to produce harder or more carburised steel than a fire-clay crucible would make under similar circumstances. Still, the difference is very small, and there is nothing easier than to make the proper allowance for it when the materials are charged. The properties of crystallised carbon or graphite are unfavourable to chemical action. It is well known that plumbago can be exposed to the highest temperature in a furnace containing a surplus of free oxygen, and that it will neither burn nor waste away to any sensible extent, while amorphous carbon, like charcoal or coke, will be instantaneously consumed under similar circumstances. A similar result is obtained by bringing liquid steel in contact with the two kinds of carbon. The amorphous carbon will be taken up with avidity, probably on account of its previous combustion and conversion into carbonic oxide gas, while the graphite will be very slowly taken up or dissolved in the liquid steel. The quantity of carbon which a plumbago crucible supplies to the steel melted in it is insufficient even for making the softest kinds of steel, and an extra dose of charcoal or combined carbon contained in the spiegel-eisen, or of graphite powder (according to the experiments made by our correspondent, "S," on plumbago steel), must be added to the charge within the crucible. It is obvious, therefore, that with some practical experience, there could be no difficulty in adjusting the charge for the graphite crucible, so as to produce the exact quality of steel desired, the influence of the crucible being allowed for. The only doubt which can remain refers to the constancy of that influence under all circumstances. With regard to this, it is clear that the fluctuations of a fraction, which is in itself so very small in amount, cannot be considerable; besides, it is the whole aim and art of steel-melting to keep circumstances as nearly uniform and constant as possible, so as to insure a perfect uniformity and reliability of the articles produced. So far the plumbago crucible has no practical disadvantage for steel-melting, but there are some great advantages to be gained from its use in other respects. In the first instance, it allows of a higher temperature than some of the average qualities of fireclay will stand, being used without danger; there is, moreover, no silica in its composition, and it has therefore no tendency to oxidise a part of the iron, and to form silicate with it, producing a surplus of slag and causing a loss of material. This latter tendency is one of the greatest faults of the fire-clay crucible, and it is probable that its injurious action shows itself in another direction still. We refer our readers to our article on "Honeycombed Steel Castings" on page 185 of the first volume of ENGINEERING, where we published the interesting results of M. Caron's experiments on this subject. M. Caron has made numerous researches upon the influence of the materials now generally employed for steel crucibles and moulds. His experiments invariably showed honeycombs and air-bubbles when steel was melted and afterwards allowed to cool in contact with any silicious material, while the same kind of steel remained perfectly sound and smooth at its surface if held in a crucible of burnt lime or burnt magnesia,

which M. Caron used in his experiments. M. Caron starts the theory that the silica combines with some oxide of iron produced in the earlier stages of the process, and that this silicate is decomposed again at a later period by the surplus of carbonic oxide thus formed, or by the carbon contained in the steel, the product being carbonic acid gas. Whether we accept this theory or not, the results of M. Caron's experiments must lead to the conclusion that fire-clay is not so suitable a material for steel-melting pots and for steel-founders' moulds as substances which contain no silica, and amongst these latter graphite is the only one which has come into practical use. Burnt lime has no consistency, and disintegrates when stored in the open atmosphere; and burnt magnesia, which can be moulded into good strong crucibles by the application of considerable pressure, is too expensive at 10 $\frac{1}{2}$ per ton for making steel-melting pots. It appears, therefore, that plumbago deserves more attention from steel-makers in this country than has hitherto been bestowed upon the material. There are some very celebrated plumbago crucible works in this country, and the Cumberland graphite has been famous all over the world for centuries past. It is now only equalled by those beautiful graphites found in Siberia, and exported from that locality to all parts of the civilised world. Some experience is required in working the graphite up into crucibles, so as to prevent their cracking in the fire or breaking under the strain exerted by the weight of steel held in them, but the crucible makers in this country are in no way behind Continental manufacturers in this respect. We need only name the Patent Plumbago Crucible Company, of Battersea, whose products have so high a standing, and so extensive an export to the Continent, that the makers have been complimented by the extensive imitation of their trade-marks and trade-circulars. It is probable that the plumbago crucible will be somewhat dearer in this country than fire-clay, particularly if each pot is used for one charge only, instead of standing three charges, as is the case with fire-clay crucibles; but the advantages of standing a higher heat, and leaving the contents unaffected by silica, are sufficiently important to make the introduction of plumbago pots desirable in many instances and for many special purposes.

THE RICHARDSON PROCESS.

WE a short time ago noticed a method of converting pig iron into malleable iron or steel recently experimented upon at the Glasgow Iron Works by Mr. Richardson, and we drew the attention of our readers to the fact that the Richardson process is but a modification of Mr. Bessemer's great invention, and that it is in its principle covered by Mr. Bessemer's original patents, which are still in force. Respecting the practical merits of the Richardson process, we have not hitherto been able to make any statement based upon facts, since the experiments made by Mr. Richardson have not as yet been very numerous, and their results could not be properly appreciated in the absence of analytical as well as of practical tests. In a letter, which we published in our last number, Mr. St. John Vincent Day communicated to us some analytical results obtained by Dr. Stevenson Macadam, of Edinburgh, to whom Mr. Richardson had sent for analysis some samples from his first experimental operations. At the same time samples of the forged and rolled malleable iron produced at the Glasgow Iron Works by Mr. Richardson's method have come under our notice. The accounts of their behaviour under treatment, both hot and cold, are very favourable, and equally so is the appearance of the fractures and of the cold bent specimens. We are told, upon the best authority, that these specimens have been made from common grey Scotch pigs, without previous refining, and in a direct charge of about seventy-five minutes. The grey iron was charged in pigs, as in the usual practice of puddling. Each charge was 4 cwt., and the furnace a common puddling furnace, settled with iron ore and cinder, as usual. After the iron had been reduced to a liquid state, a blast of air was introduced through the so-called tubular rabble, or, as it may be more correctly described, a movable blast-pipe branching out into several small nozzles or tuyeres at the end. The rabble being dipped into the molten iron, the blast of air, subdivided into numerous jets, was forced through the mass of molten iron from near the bottom, and the ascending currents of air effected in the puddling furnace the same succession of changes and phenomena which are known to take place on a larger scale in the Bessemer converter. The increase of temperature, the "boiling," and the successive stages of decarburisation, were observed with great facility, and occupied the comparatively short time of

less than ten minutes. After that the blast pipe was withdrawn and the process of puddling carried out in the same manner as if the iron had "come to nature" without the assistance of the blast. The result was unquestionably better than that obtained by the common puddling process, and that in two respects. First, the time of the operation was reduced from 1½ hours (which is the best average of working with Scotch grey pig iron) to 1¼ hours. This saving of time is equivalent to a proportionate economy of fuel burnt in the grate of the puddling furnace, and to an economy in plant and labour by the increase of the number of heats which can be worked in a furnace from six per day to eight or nine heats. The second advantage gained is the high quality of iron obtained from inferior kinds of pigs by this process, and, as far as can be judged from the early experiments, the comparatively small waste of iron during its conversion. The analysis of Dr. Macadam shows a remarkable purity of the malleable iron, which, if borne out by future experience, would place the Richardson process amongst the most important improvements in modern metallurgy. Dr. Percy's ingenious and plausible theory for explaining the purification of the metal from sulphur and phosphorus in the puddling furnace as compared with the impossibility of removing these substances in the Bessemer converter, is perfectly sufficient to meet the difference between the Bessemer process and the Richardson process. According to this explanation, the solid or pasty mass of iron is separated mechanically from the more liquid phosphides in the process of balling, while the iron or steel remains mixed with the latter when the whole contents of the converter are cast into ingot moulds. There is nothing, however, in this or in any other theory as yet brought forward which would explain the reason why the Richardson process should be more efficient in purifying the iron than the common puddling process, since the balling takes place in both alike. In this respect, we believe the time for theorising has not fully arrived yet. Let us first ascertain the facts, and then there will probably be no difficulty in finding some method of explaining them. In asking for facts, we do not desire to question the accuracy and reliability of those already obtained by Mr. Richardson and his friends; but we consider the number of these data far too limited to be safely and without the risk of serious errors generalised into anything like a theory. We prefer therefore, at this early stage, to look upon the Richardson process only as a means for economising time and fuel in puddling, and, considered from this single point of view, this process appears sufficiently important to deserve the utmost attention of ironmasters and engineers. The Richardson process appears at present as a compromise between the old-established puddling process and the modern methods of atmospheric decarburisation, but it is more than probable that its successful introduction may at some future time form the stepping-stone from our present system of hand labour to that long but hitherto unsuccessfully aspired achievement of mechanical puddling.

LOCOMOTIVE ECONOMY.

(Continued from page 392.)

EVERY locomotive engineer has had occasion to estimate, although perhaps not at its full value, the advantage of uniformity of design in a considerable stock of engines, of which nearly all parts are readily interchangeable. On but few, if any, lines, however, can a single type of engine be maintained intact, or be made to properly serve the various requirements of the traffic. The light express and the heavy express, making but few stops,—the mail train, stopping often,—the excursion, the parliamentary, and the branch line trains, the mineral train, the fast goods and the ordinary goods train—all require different engines; and many lines have gradients, upon different portions, so different from each other as to require a special class of engines for each portion or division. Then there is the constant growth of traffic requiring heavier and often faster engines, and there is always the risk of a change of locomotive superintendents, such as has happened so often upon the Great Eastern line, which has, we believe, about sixty different types of engines, representing the talent of half-a-dozen locomotive engineers. New men, animated by new ideas, have successively inflicted upon it inside cylinders, outside cylinders, and inside cylinders again, tank-engines and tender-engines, large-wheel and small-wheel goods engines, and, indeed, almost everything upon engine-wheels, until it would almost seem that, as an eminent locomotive engineer once remarked, while surveying the heterogeneous stock, "anything will do, ANYTHING

will do for a locomotive!" Were the locomotive stock of this line to be now reconstructed, six types at most would meet every requirement, and of these many parts might be interchangeable.

But we must here leave general questions for details, and among the most important of the latter are those which keep an engine running longest without attention and without going into the shop. There is often trouble with the slide valves, not yet relieved of pressure, as they should be, either by Thomas Adams's plan or by Bristol's rollers, so widely used in the States, and which some English locomotive superintendent should really have the courage to try (writing for particulars to Mr. Daglish, of St. Helen's). In the mean time, it is common to drill shallow holes, with a tapering drill, into the face of the valve, and to fill these with "patent metal." Not long since, on the Manchester, Sheffield, and Lincolnshire line, valves thus faced were found to be "scrooping," but this after a time ceased, and they were found to be working uncommonly well, and the engine burning less coal than before. On examination, it was found that the white metal had melted out, and that the valves were working with empty holes in their faces. Mr. Sacré informs us that he now finds a decided advantage in merely drilling the face of the valve with shallow holes (taking care that they shall not be in line in the direction of motion of the valve), and we believe the valves of nearly all the engines on his line are now so drilled. They are found to work much more easily than before, and do not leak steam as might, perhaps, have been expected.

A means of economy still neglected on some lines is that of fitting every wearing surface, except the parts working in steam, with oil-cups, wicks, and trimming wires. The engines in course of construction by the Yorkshire Engine Company, at Sheffield, have oil-cups and trimming wires fitted to the upper ends of the links, one to each wearing face, and to every joint of the valve gear, so that these parts will be kept constantly oiled, throughout a long journey, without further attention after the first charging.

And while upon the subject of oiling we cannot avoid saying that it is time that every grease-box for axle-journals was removed and pitched into the scrap-heap. Railway shareholders have no conception what these barbarous makeshifts for lubrication cost in locomotive power, especially in cold weather. They greatly increase the resistance to traction as compared with proper oil-tight oil-boxes as used upon the North London and a very few other lines. We can authenticate cases in which the traction of loaded goods wagons, the journals being lubricated with oil, was as low as 5 lb. per ton, whereas nothing below 8 lb. is recognised as possible with our grease-boxes as almost universally used. In the very important series of experiments made by MM. Vuillemin, Guebbard, and Dieudonné, and embodied in the *mémoire* presented by them to *La Société des Ingénieurs Civils*, in competition for M. Perdonnet's gold medal, the resistance of trains lubricated with grease was one-half greater in cold weather, say, at a little below the freezing point, than at the temperature from 59° to 68°. With oil no difference attended the variation of temperature (see *ENGINEERING*, October 25th last, page 385). We gave a description of the best form of oil-box for railway axles—the Lightner box, as used on the North London line—more than a year ago (see page 178 of our second volume). This box may be opened, and the brass removed, in less than one minute. Once charged with oil, it will run two months without examination or replenishing, although for passenger carriages it should be filled, as a rule, once a month, a book being kept by the carriage inspector, with the number of each carriage and wagon, and the date of filling the boxes being regularly entered in it.

Every locomotive engineer knows the importance of preventing "knocking" in the driving axle-boxes, and it is partly because of their greater tendency to knocking that outside cylinder engines are not in general favour on English lines. With large cylinders, and steam of from 130 lb. to 160 lb., the strain upon the forward side of the axle-box is necessarily great. It is becoming very customary to apply wedges to the driving axle-boxes, as has been done for many years abroad, where only outside cylinders are preferred. But the wedges do not take up the wear where it goes on fastest, viz., in the axle-box itself. It is a question whether the box should not be made in halves, divided vertically, and separated by an elastic substance yielding to tightening bolts when the box has worn. The wearing surface upon the horn block would then more than ever require to be adjustable. It is an important question, which could, and should, be settled by experiment, whether axle-boxes fitted with wood

and lubricated with water, in the manner of Mr. Penn's wood bearings, as used for the stern tubes of screw-steamers, could not be employed with advantage for driving axle-boxes, and even for all axle-boxes. For driving axle-boxes, at any rate, the wood would prove almost indestructible, and all knocking would thus be prevented.

Wherever four coupled wheels are used—and their use is now very general—compensating levers should invariably be employed between them. None who have used these levers would ever consent to do without them, although they should not be applied between all the springs of six-coupled engines. But for compensating levers, the American engines (to which they are invariably fitted) could never ride as easily as they do over the rough lines to be found in some parts of that country. We fear that the action of compensating levers in dividing and distributing the force of shocks due to irregularities on the line is not understood as it deserves to be. On the occasion of the discussion upon Mr. Robinson's paper, read before the Institution of Mechanical Engineers, in May, 1864, one eminent locomotive engineer observed that he had so far done without compensating levers, and he conceived that the driving-wheels, when without these levers, acted beneficially in *planing down* irregularities in the line! Upwards of forty gentlemen heard this astute opinion pronounced, and we ourselves listened to it, but it was not allowed to appear afterwards in the printed Transactions. Compensating levers, even in the opinion of Mr. Robinson (of Sharp, Stewart, and Co.), who was advocating their use, seemed to be considered as expedients only for effecting a certain desired distribution of weight, whereas their chief useful effect is to lessen the force of shocks due to irregularities in the line. Their action, in this respect, is easily studied and easily comprehended, and it is of much value in all coupled engines.

The breaking of crank-axes was once the most serious objection that could be urged against inside cylinder engines. Steel cranks are now extensively used, and they very seldom break. A form of crank has been largely introduced in the States, which is much approved of, and a few of these have been made in Sheffield, by Vickers, Sons and Co., to the order of the patentee, Mr. Dyer Williams. They are made each in nine pieces, the cheeks or throws being bored to receive the cylindrical portions, which are secured by keys and pins. The bored holes, and the parts turned to fit them, are tapered 1 in 100 in diameter, or 1 in 200 along either side, and the parts are forced home by hydraulic pressure. Perfectly sound cranks can be made in this way at a moderate cost, and there is no more chance of the parts working loose than of a driving-wheel working loose upon its axle.

(To be continued.)

A NEW SUGAR REFINERY AT GREENOCK.—The already enormous trade in sugar-refining at Greenock is to be still further greatly increased, if we may judge by the extensive fire-proof refinery which is now in course of erection at Dumfries-road, for Messrs. Neill, Dempster, and Neill. The main building is nine stories in height, surmounted by a water-tank, which serves as a roof, besides supplying the refinery with water. On the western extremity of the north side of this building is a square staircase with a hoist in the centre, by which the refined sugar, when dried in the centrifugal machines, is to be hoisted in boggles or carriages, whence it is to be run along a gangway into an adjoining store further north, where it will be dried and casked. To the south of the main building is the char kiln house, and further south still are the engine-house and steam-boiler house. The cooperage is to be two stories in height, with water-cistern on the top, forming the roof. The chimney-stalk will be square, 140 ft. in height, 13½ ft. wide at the base, and, in common with the other buildings, will be ornamented in white brick. The building is already in a pretty forward state. Messrs. Alex. Whitelaw and Co. are the builders. The refinery when completed will present a very imposing appearance, and may be expected to be in full operation within less than a year. It will embrace all the most recent improvements connected with the refining trade, and, indeed, will be quite a model house. Messrs. Blake, Barclay, and Company are the architects and engineers of this monster refinery. In a subsequent number of *ENGINEERING* one or more illustrations of this new refinery may be given.

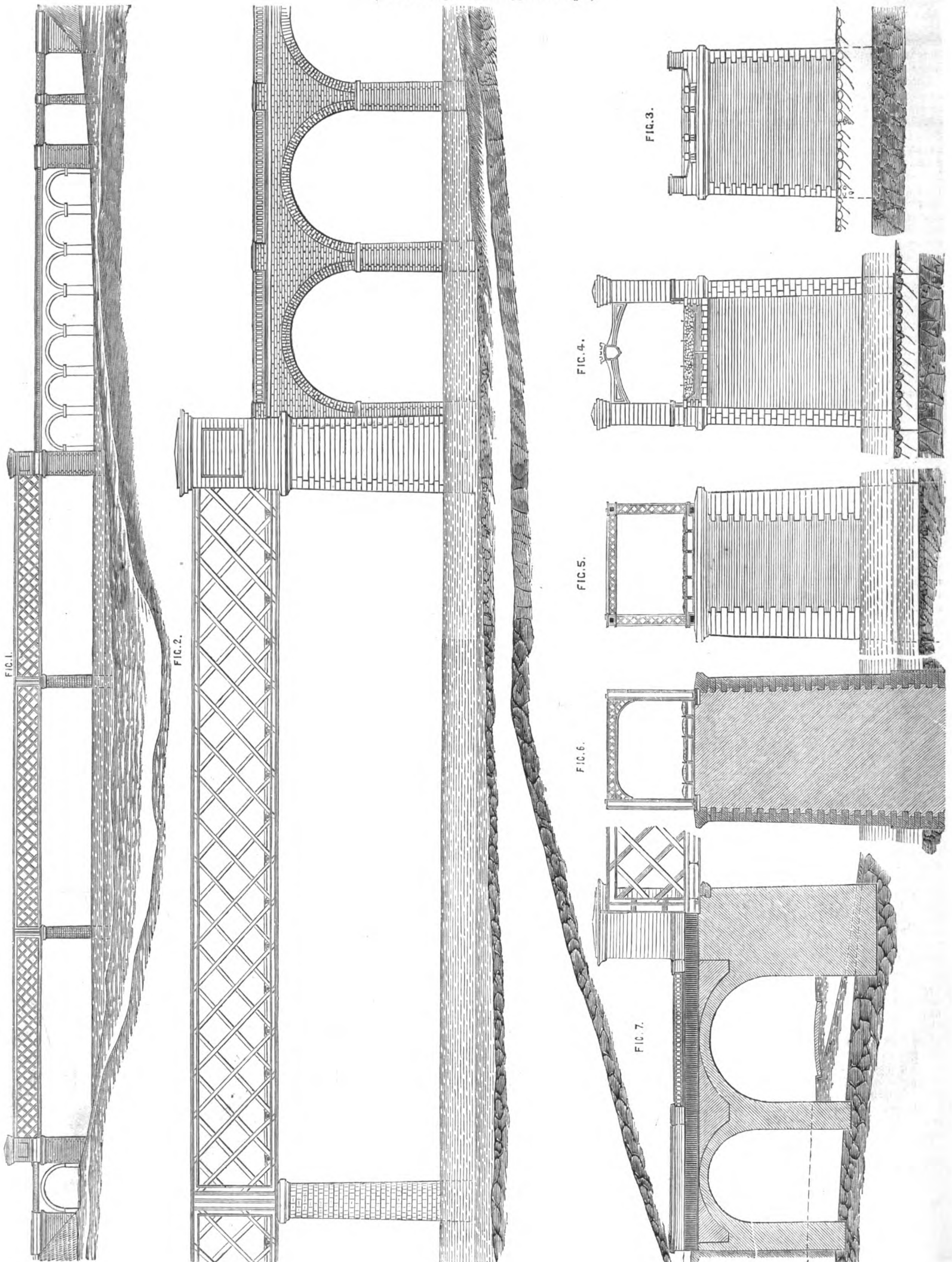
PAISLEY—NEW BRIDGE ACROSS THE CART.—Operations have been in progress for some time for the erection of a bridge across the Cart to connect the extensive thread works of Messrs. J. and J. Clark, at Seedhill, with their factories at Lonend. Substantial stone piers, for the support of the bridge at each side of the river, have just been built, and workmen are busily engaged with the preparations for carrying the girders across. Messrs. Craig, Fullerton and Co. are the makers of the bridge. It will be 96 ft. in length and 12 ft. in width, within the girders. The bridge will be capable of sustaining a weight of 50 tons, and will have a horse-track running between the girders, with a footpath 3 ft. wide on each side.

LEEDS.—The forges are stated to be slack; only a few are making more than half time. The machine shops and locomotive builders are also slack, but there is a good deal doing in steam ploughs, Messrs. Fowler being full of orders.

BRIDGE OVER THE RIVER SCORFF, AT LORIENT; PARIS AND ORLEANS RAILWAY.

MM. DIDION AND MORANDIERE, ENGINEERS.

(For Description, see opposite Page.)



BRIDGE OVER THE RIVER SCORFF, AT LORIENT; PARIS AND ORLEANS RAILWAY.

MM. DIDION AND MORANDIERE, ENGINEERS.

THE bridge, of which we give engravings on this and the opposite page, carries the Nantes and Châteaulin Railway—a line forming a portion of the Paris and Orleans Company's system—across the river Scorff, near Lorient. The structure, which carries two lines of rails, comprises a masonry arch of 32 ft. 10 in. span on the left-hand side of the river; three main spans having clear openings, two of them of 170 ft. 7 in. and the other of 210 ft.; and nine openings on the right-hand bank of the river, of 32 ft. 10 in. each. Seven of these latter openings are spanned by masonry arches, and the other two by iron girders, as shown in Figs. 2 and 7. The total length of the work is 1076 ft., and the girders spanning the main openings are placed at a clear height of 41 ft. above the mean water-level.

The masonry portions of the bridge do not present any peculiar features. They were founded upon the rock by excavation. The existence of a thick bed of silt, the great irregularity of the surface of the rock, and the influence of the strong tidal currents rendered the putting in of the foundations of the large abutment pier on the right-hand bank and of the small piers following it, a matter of considerable difficulty. The obstacles were, however, surmounted, and the work executed with sufficient rapidity by the employment of a bottomless caisson for the abutment pier, and of cofferdams connected to this caisson for the smaller piers.

The parts of the work possessing the greatest interest are the foundations of the piers of the main spans and the main girders themselves, together with the means employed for getting them into position. The foundations of the two piers carrying the main spans were put in by the aid of chambers filled with compressed air, the system followed being the same as that used at the Kehl bridge. The area of the foundations to be constructed being, however, less than in the case of the Kehl bridge, the arrangements were considerably simplified and the expense proportionately reduced. The foundation of the one pier was put in at a depth of 69 ft., and the other at a depth of 50 ft. below high-water mark.

The apparatus employed for putting in these foundations consisted of three parts:—1st., the working chamber forming the base of the arrangement, and in which the excavation was performed; 2nd., the caisson, or coffer-dam, properly so called, placed above the working chamber, and in which the erection of the masonry was carried on in the open air; and 3rd., the equilibrium chambers situated at the upper part of the apparatus, these chambers being connected with the working chamber by vertical cylindrical passages, and being furnished with suitable air-valves.

The working chamber was 39 ft. 9 in. long, by 11 ft. 5 in. wide at the bottom, and 10 ft. high. The exterior shape in horizontal section was the same as that of the pier itself; but the interior outline consisted of a series of arches abutting upon crossbeams of cast iron, in such a manner as to expose great resistance to the external pressure of the earth. The interior shell was formed of three successive sections, the thicknesses of which, commencing at the bottom, were .57 in., .39 in., and .31 in. respectively. The lowest section was also strengthened at the base by four other plates of the same thickness, disposed so as to break joint, and strong angle-irons placed at the junctions of the sections assisted greatly in stiffening the whole. The ceiling of the working chamber having to support during the progress of the work the whole weight of the masonry up to the water level, was of a slightly arched form, and its framework was composed of four main transverse girders, each 2 ft. 3½ in. in depth, and four ranges of smaller longitudinal beams, 8 in. deep, upon which were rivetted the iron plates, .39 in. thick, which formed the ceiling, or platform proper.

The caisson, or cofferdam, placed above the working chamber, was composed of a series of horizontal sections, formed of plates, the thicknesses of which diminished towards the top, being successively .2 in., .16 in., and .12 in. These sections were put together one after the other as the work of sinking the foundations proceeded, care being taken that the upper edge of the cofferdam thus formed was always above high-water level. The working chamber weighed—including the cast-iron crossbeams—27 tons, and the mean weight of the caissons used for the two piers was 15 tons, so that the weight of metal in the apparatus used for sinking each pier averaged 42 tons.

The equilibrium chamber consisted of a cylinder 8 ft. 2½ in. in diameter and 9 ft. 10 in. in height, the lower end of this cylinder being placed in communication with the working chamber by intermediate cylindrical passages, and the upper end being fitted with a pair of air-valves of the same construction as those used at the Szegedin bridge and other works of a similar nature. In getting the caissons into place it was necessary to pass through a layer of silt 46 ft. thick in the case of the pier next the right-hand bank of the river, and 26 ft. thick in the case of the other pier. In the latter instance the silt was very soft, and the caisson had a strong tendency to tilt and get out of place, whilst the considerable variations of pressure due to the action of the tidal currents also increased the chances

of accidents. The rock also presented a very unequal surface and much excavation had to be done to get a fair bearing for the piers. The construction of the foundations thus required much care, and the precautions which it was necessary to take somewhat delayed the progress of the work. The time occupied in constructing the foundation of each pier was, however, but three and a half months, this time not including that occupied in getting the apparatus into position.

Upon the required depth being attained, the working chambers were filled in with cement, concrete, and masonry, set in Portland cement. The upper part of the filling consisted entirely of masonry with granite facing, this system of construction being adopted on account of the expected limited durability of the casing plates in the sea-water to which they are exposed. Above the foundations the piers are constructed entirely of masonry, as in the case of ordinary bridges, the face-work being of cut stone. The cost of the two piers was 8400 £.

The superstructure of the three main openings consists of trussed girders, as shown in the engraving, the figure on the present page being an enlarged section of one of the girders, and showing its construction clearly. The girders are 20 ft. 10 in. deep between top and bottom flanges, and each is formed with a double system of bracing, as shown in the section. The transverse girders rest upon the bottom booms of the main girders, and the top booms of the latter are well braced together by lattice beams, as shown. The top and bottom booms are of trough section, each being composed of a pair of vertical plates placed 19½ in. apart, and to which the diagonals are attached, and a horizontal flange. The horizontal flanges are 2 ft. 7½ in. wide, and are formed of plates .39 in. thick, the number of these plates varying from three to six, according to the section required. The vertical plates and horizontal flanges are connected by double angle irons, and angle irons are also rivetted to the edges of the vertical plates. The sections of the diagonals of course vary according to their position; there are no vertical struts or ties, but over the piers the diagonal bracings are replaced by plate-webs stiffened by T-irons. The transverse girders are of the ordinary I section, 2 ft. 5½ in. deep, and placed at a distance of 10 ft. 2½ in. apart from centre to centre. They are connected by longitudinal girders 1 ft. 7½ in. deep, on which the longitudinal timbers carrying the rails directly rest. The weight of iron in the superstructure of the main spans averages 3150 lb. per foot run.

The girders, which are continuous, were put together on the left-hand bank of the river, and were then hauled into their position by hydraulic power. Whilst being thus moved, they were carried on rollers, and the foremost end of the bridge was provided temporarily with a kind of cutwater or inclined plane, which projected in front of it and guided the end on to the piers, thus obviating any stoppage which might have been caused by the deflection of the overhanging portion. The bridge, after being completed, was thoroughly tested, and on the removal of the loads the girders were found to take no permanent set.

The masonry portion of the bridge was executed in the space of about one year. The ironwork was commenced in October, 1861, and completed in September, 1862, or in about eleven months, this time, however, not including the time occupied in preparing the plates at the works of the contractor.

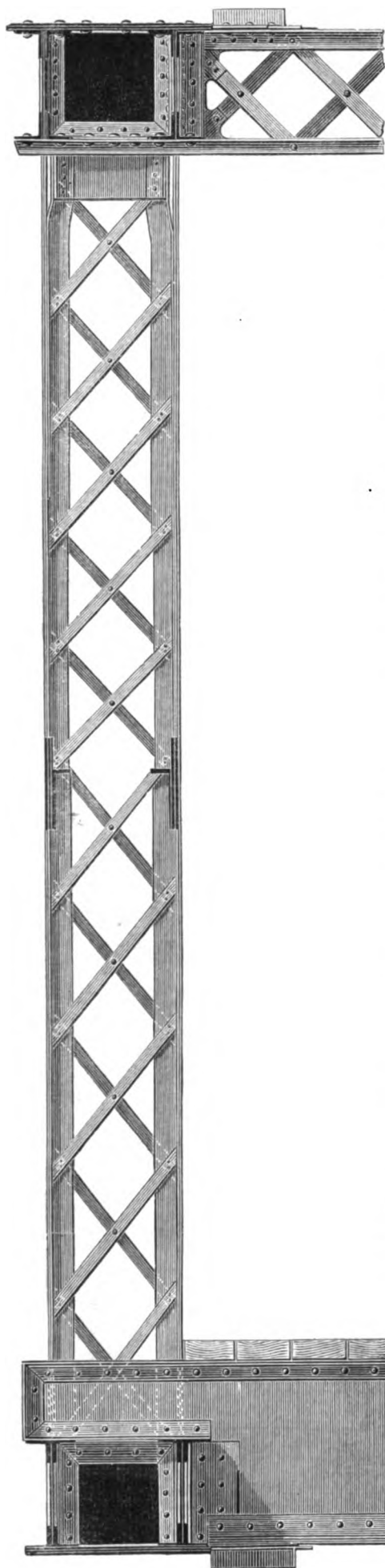
The cost of the Scorff bridge was as follows:

	£	s.	d.
Masonry portion (508 ft. 6 in. long) ...	23,360	16	0
Main spans (length 567 ft. 6 in.) ...	£	s.	
Foundation of main piers ...	8,400	0	
Masonry of piers above foundation ...	3,369	12	
Superstructure ...	22,069	12	
	33,839	4	0
Total cost	£57,200	0	0

The cost per foot run was thus:

	£	s.	d.
For masonry portion about ...	46	0	0
„ main spans ...	59	6	0

The bridge was designed by, and the works executed under the general direction of, M. Didion, inspector-general of Ponts et Chaussées, and general director of the administrative council of the Paris and Orleans Company; and M. Morandière, engineer-in-chief of Ponts et Chaussées, and director of the new works on the western division of the Paris and Orleans Company's lines. The engineers who had immediate charge of the work were M. Croizette Desnoyers, engineer-in-chief of the Ponts et Chaussées and engineer-in-chief of the railway company's lines in Bretagne and Vendée, and M. Dubreil, engineer of Ponts et Chaussées. The chief of the section of the company's lines on which the bridge is situated is M. Guillemin. The ironwork for the bridge was constructed, from designs furnished by the railway company, by MM. Ernest Guin and Company, at their works at Clichy, and the contractors for the masonry portion of the work were MM. Clairin, Leturc, and Blanche.



INSTITUTION OF ENGINEERS IN SCOTLAND.

THE first general meeting of the eleventh session of the Institution of Engineers in Scotland, with which is incorporated the Scottish Shipbuilders' Association, was held in the Philosophical Society's hall, on Wednesday evening—Mr. J. M. Gale, engineer to the Water Commission, in the chair.

The report of the council was read. We extract what follows:

In submitting the usual annual report at the beginning of this the eleventh session, the council have much satisfaction in being able to congratulate all interested upon the continued extension and energy of the institution. The library is in a satisfactory condition; most of the periodicals, pamphlets, and unbound books have been bound in a form which renders them more easy of reference. During last session a large number of books were added to the library, the greater part of which were gifts from authors, honorary members, and members of the institution. At the present time, the institution receive, in exchange, the transactions of several kindred societies, and a number of periodicals. The library now contains many books of a theoretical and practical nature, valuable for reference and general reading. A new and extended catalogue is now being prepared, and will be issued shortly. It is a pleasure to the council to notice the continued accession to the strength of the institution. During last session there joined the institution 24 members, 1 associate, 4 graduates, making the number on the roll at the end of last session—hon. members 10; members, 311; associates, 57; graduates, 18; in all, 386. For papers which may be read during the ensuing session, the following medals are offered for competition:—the Railway Engineering Medal, for communications on railway engineering and practice; the Marine Engineering Medal, for communications on subjects on marine engineering; the Institution Medal, for subjects not comprehended by the railway or marine engineering medals.

Mr. J. M. Gale, the president, then proceeded to deliver his introductory address, in the course of which he spoke first of

The Institution.

The origin of the institution dates from a very successful meeting of the "Institution of Mechanical Engineers," held in this city in 1856. It was formed in March of the following year, and, under the presidency of Professor Rankine, held its first meeting on the 28th October, 1857, and at once took a high position. At the end of the first session, the number of members of all classes was:—first session, 1857-58—members, 118; associates, 1; graduates, 8; hon. members, 0; total, 127; and at the end of the tenth session, 1866-67—members, 311; associates, 57; graduates, 18; honorary members, 10; total, 396. This rapid increase is highly satisfactory, and augurs well for the future. The funds of the institution also are in a satisfactory position. The subscription fee now amounts to 550*l.* per annum, while the revenue last year was more than sufficient to cover the expenditure, and the capital account shows a balance in our favour of about 675*l.* The amalgamation of this institution, as originally constituted, with the "Scottish Shipbuilders' Association," which was effected during the eighth session, has, and I believe will continue to conduce very much to the benefit of both societies. Of the value of such an institution as this to men engaged in designing and constructing large works we have the best possible proof in the increasing numbers and importance of similar societies throughout the country, and in their transactions contributing so largely to our professional literature. Everything new in principle and arrangement is brought under review, the cause of failure of plausible theories is explained, and anything unground in received ideas is exposed. That there has been great progress made in engineering science and practice within the short space of ten years since the institution was formed is quite evident to us all. A simple enumeration of the great works that have been executed, and of the improvements that have been made in mechanics and engineering within the last ten years, improvements resulting in substantial saving of time and money, and increase of production, would, were I capable of making such a list, occupy more time than the limits of an address would admit; but there are a few large undertakings to which I will refer, and some things which have either been used for the first time since this institution held its first meeting, or which have been much improved or more largely used since that time.

The Steam-Engine.

And, first, in the steam-engine, we have surface condensation, which, though early proposed, but few were in use in 1861, when the subject was brought under the notice of this institution by Mr. Thomas Davidson. It is now largely applied, and its benefits thoroughly understood, and it must be a source of satisfaction to those gentlemen who, along with Mr. Davidson, advocated at that time the adoption of the principle to see it now employed so much. Its advantages are a saving of fuel, brought about by supplying the boilers with the pure water obtained by the condensation, instead of with salt water, and so avoiding to a great extent the forming of the scale of lime and magnesia inside the boiler; the saving of a great part of the power necessary to work the air-pumps, and the obtaining of a more perfect vacuum. In steam-engines of all classes the advantages of using high-pressure steam, and a high rate of expansion, are now generally admitted and acted upon. Double-cylinder engines, which allow of the use of high steam without risk of breakage of the working parts, and of a high rate of expansion at the same time, are now largely used, and some very fine examples of these compound engines have lately been made in this city by members of this institution. In pumping-engines, the old single-acting non-rotative Cornish engine, to which Watt gave so much attention, and brought to such a high state of perfection that no substantial improvement has been made in it since it left his hands, is now giving way, where there is no pump-rods to absorb the first blow of the steam on the piston, the double-acting condensing rotative beam-engines, with, however, all the means of economising fuel retained, which are so prominent in the Cornish engine, including the Cornish boiler, a slow rate of evaporation, a high pressure of steam, a great expansion, and jacketed cylinders. The use of high steam cut off at

an early part of the stroke in the Cornish engine as applied to raise water for the supply of a town, involved repeated breakages of the main-rod, piston-rod, and other principal parts of the engine; and these accidents led to the use of lower steam and less expansion, and a consequent reduction in the efficiency of the engine. In first cost it is more expensive than the double-acting engine, as it only does duty one way, and the flow of water in the main thus made irregular. The engines at present being erected, and those that have been erected during the last four or five years in connexion with the main drainage of London, amounting in all to upwards of 2300 horse power, are all expansive, condensing, double-acting, rotative beam engines, and from these engines a duty of 80,000,000 foot-pounds per cwt. of Welsh coal is obtained. As good results have been obtained by the use of high-pressure, condensing, double-cylinder engines, and even with single-cylinder double-acting engines, as with the Cornish engine. A pumping-engine with double cylinders and large fly-wheel is as satisfactory a machine as can be made, and expansion can be carried farther with it than with the Cornish. A good many engines of this class have lately been put up in connexion with the different works supplying London with water.

Railways.

Within the last ten years great progress in railway works has been made, both on the continents of Europe and America and in India. In this country the most prominent extensions of the railway system have been within the more densely built portions of London, executed at vast expense, and in the face of difficulties calling for the highest effort of engineering skill. Among these we have the highly successful underground railways, for which Mr. Fowler is the engineer, and at least three magnificent bridges across the Thames. The means adopted for regulating the immense traffic on these railways is most complete and efficient, and the new passenger stations are of great extent. The subject of adapting locomotives for the working of steep gradients has received a great deal of attention within the last few years, with a considerable amount of success; and a good climbing engine has at length been invented by Mr. Thomas Page for Alpine locomotion. The driving-wheels of the locomotive are made broad, and bite into a broad tramway of roughened stone laid alongside the rail, affording great friction. Tramways of wood have also been successfully tried, and in this shape it would make a cheap road applicable to a rough country where moderate speeds only are wanted. But the most successful adaptation of the locomotive to steep inclines is the railway recently opened over Mount Cenis, and constructed under the direction of Mr. Fell. The railway is laid down on the bed of the road over the pass by Mount Cenis from France into Italy, and close to the tunnel already described. The gauge is 3 ft. 7½ in., and the space left for the road traffic is in no place less than 16 ft. The length of the line from St. Michael, on the French side, to Susa, on the Italian side, is 48½ miles, and the whole work was completed in eighteen or twenty months. The distinguishing feature of the Fell railway is its central rail, which is raised 9 in. above the other rails, and is gripped by four horizontal wheels, with which the locomotives are furnished, in addition to the usual vertical wheels, and which can be acted upon by the steam from the same boiler and in the same manner as the vertical wheels, and thus affording a greatly increased adhesion. In connexion with railway construction, I may further mention the extended use of cast-iron cylinders for the foundations and piers of bridges in soft material, a fine example of which has lately been very successfully erected across the Clyde in this city; and of the cast-iron tressel girder, which seems about to supplant entirely the plate girder for large spans. We have also the fish-joint, and the introduction on a large scale of steel rails, which of itself is sufficient to mark an epoch in engineering science. Before leaving the subject of railways, I would wish to make a single remark about a subject that at present must present itself to every one's mind when railways are mentioned. I mean the fact that there are at present five of the large railway companies of this country in a state of bankruptcy, and that the value of our railway property is less by about 150,000,000*l.* than it was eighteen months ago. We have the satisfaction of knowing that this state of matters has not been brought about by any shortcoming on the part of the engineers. It is not because viaducts are coming down, or bridges being washed away, or that a permanent way and rolling stock sufficiently strong and durable cannot be manufactured; it is not that the works designed by the engineers have been found totally inadequate to meet the requirements of railway traffic, but it is from causes which, I am happy to say, do not form any part of the functions of this institution to discuss.

Canals.

Notwithstanding the great development of railways, canals will always hold a first position, as a means of transit, because of the economy attending the transmission of heavy materials along them, where speed is not an object. The subject of introducing the screw upon the canals, now so general, was brought before the institution during the first session, by Mr. Neil Robson, who described the first successful trials on the Forth and Clyde and Monkland Canals of the steam-lighter Thomas, which may be looked upon as a corollary to the Charlotte Dundas. The most important canal work of the present day, or indeed of any previous age, is the Suez Canal, which, notwithstanding the forebodings of commercial failure by many eminent engineers of this country, is rapidly approaching completion. It is a scheme to connect the Mediterranean with the Red Sea, on the main route from Europe to India and the East, by a ship canal of colossal dimensions, without locks. The distance between the two seas is 90 miles, about 30 of which are through lakes and depressions below the level of the sea; but in the remaining 60 there is some heavy cutting, the ground rising at one place 66 ft. above the level of the sea. The greater part of the earthwork is being removed by dredging, and the canal is to be of sufficient depth and width to allow ships of the largest class to pass freely through, and is to have basins or harbours at each end. About 8,000,000*l.* has already been expended upon works alone, while the total expenses of the company amount to upwards of 15,000,000*l.*, and other 4,000,000*l.* are wanted to complete the enterprise. The objec-

tions urged against this project were many and various, but the principal were, that the drifting sands of the desert through which it passes would fill up the canal, and that the moving sands on the coast would fill up the entrances, especially that on the Mediterranean side; but the experience of some years warrants the engineers of the undertaking in stating that a moderate amount of dredging will keep the canal clear of drifted sand, and that sand does not travel past the entrance to it on the Mediterranean side; and there, therefore, seems every prospect of this extraordinary undertaking being brought to a speedy and successful completion.

Shipbuilding.

As regards shipbuilding, I can do no more than refer to the great improvements in form, in speed, and in construction that have taken place within the last few years, to the enlarging of the size of ships, the increasing use of iron, of steam, and of the screw, and to the vast increase of iron shipbuilding on the Clyde. The last ten years have mainly contributed to the total abolition of wooden ships of war, and to the almost total renewal of the navies of the world, in many strange shapes, in which the old shipwright is not recognised, and in which propulsion by steam and thick iron-plating form the new means of attack and defence. In ordnance, too, there has been a great increase in the size, weight, and power of the guns; while in small arms the field of Sadown awoke the world eighteen months ago to the fact that a revolution had taken place in the manufacture of the rifle. Harbours are being enlarged in almost every part of the kingdom; and those works executed within the last few years upon the Clyde by Glasgow engineers, will not suffer in comparison with any in the country. Among improvements in harbour works, I may mention the double-steam-dredger, discharging over the side, and the conveying of the dredged material to the open sea, at a great saving of money over the previous methods pursued; the improvements in pile-driving, and in getting foundations for quay walls and docks in deep water without coffer-dams.

Sanitary Engineering.

The progress of sanitary engineering has also been great within the last ten years—the old cesspool system has, we may say, entirely disappeared, the mistakes at first committed in using tile pipes of improper size have been rectified, and almost every town of note has been properly and efficiently drained. This, together with the increase of water-closets in dwellings, has, in the fouling of our rivers and streams, produced an evil almost as great as that removed. The largest drainage operation of the last few years, and, in fact, the greatest ever executed as a whole, is the main drainage of London, which has for its object the efficient drainage of the low lying parts of London, and the purifying of the Thames by intercepting the sewage and carrying the refuse of the population to a distance from the city. The works consist of lines of intercepting sewers on both sides of the river, with pumping-engines of 2400 horse power to raise the low-level sewage to a sufficient height to carry it to the outfall, which is twelve or fourteen miles below the city. The works are capable of discharging 400,000,000 gallons a day in time of flood, and their cost has been 4,100,000*l.* These works have been quite successful in diverting the sewage and purifying the Thames as it passes through London; but the general question of how the pollution of our rivers is to be arrested, and what means are to be adopted to purify those already so foul, as some of them are, as to be dangerous to the public health, is the only great engineering question of the day which remains without a definite solution, at least a solution based upon a great practical example. Many attempts have been made to extract from town sewage the valuable ingredients it contains, sometimes at great cost, and often at considerable loss; and it has been shown that a portable manure cannot be manufactured from ordinary sewage water, and that its application by hose and jet in small quantities over a large area of land cultivated in the ordinary manner is impracticable. The immense volume of sewage water is one of the principal difficulties of the case, and the idea of separating the offensive parts from the ordinary house drainage, and from the rain-water, by a double set of drains has been proposed again and again. If our houses and cities had originally been constructed on this principle, it is possible that the water-closet refuse would have been more valuable than it is in its present state of dilution; but whether in the majority of our towns a sufficient fall could have been given to those drains from which rain water is excluded, that they would keep themselves clean is a matter of great doubt. To carry out this system now would involve not only a double set of street sewers, but a double set of house drains also, and an amount of disturbance of internal house arrangements, at a vast expense, which makes the proposal altogether impracticable. The Paris system, that of collecting the water-closet refuse in an air-tight tank attached to each block of houses, has been advocated very frequently and with various modifications; but the fact that the tanks are not air-tight, and that the manufacture of a manure from their contents is not attended with profit, make it, apart from the expense, which would be nearly as great as a double system of sewers, as impracticable as the other. We must deal with the sewage in the state of dilution in which we find it; and after a most lengthened inquiry it is now pretty generally acknowledged that, taking the cost of works into account, the system of irrigation practised at Edinburgh, Croydon, and elsewhere, is the only possible solution of the question. It is probable that in a city like Glasgow there may be waste products from some manufactories which are inimical to vegetable life. Such products will very generally be hurtful to animal life also; and I think communities would be quite justified in demanding that these peculiar operations should be performed at a distance from dense masses of population, or that the refuse matters should be treated in such a manner as to render them innocuous before they are discharged into the sewers of a city.

Water Supply of Cities.

The last class of works I shall mention are those for supplying towns with water, and the last ten years have given us a good example from each of the four sources available for this purpose, these are—1st, the Loch Katrine Works, which

draw their supply from a lake; 2nd, the Aberdeen Works, which draw from a river; 3rd, the Dublin works, with their large artificial storage reservoir; and 4th, the Passy artesian well at Paris. The Loch Katrine Waterworks for the supply of this city have been so frequently described, and are so well known that I need say little of them here. It is the largest work of the kind which has been constructed since the days of Imperial Rome. Those approaching it in extent are the New River Waterworks in London, which supplies about 27,000,000 gallons a day; and the Croton aqueduct, which supplies New York, can deliver 35,000,000 gallons a day; but the Loch Katrine aqueduct could supply Glasgow with 50,000,000 gallons a day. The extent to which the lochs embraced in the scheme can be drawn upon affords a storage capacity of 9000 million gallons, the total length of the aqueduct is 34 miles, and the whole works were completed in four years at a cost of about 900,000*l*. The new works for supplying Aberdeen with water draw their supply from the river Dee, at a point about twenty miles above the city. The water of the Dee is remarkably soft and pure even during floods, as the water-shed of the river consists principally of granite, and as the flow in the stream is sufficient at all times for the purposes of the works, large artificial storage reservoirs are not required. The principal feature of the new waterworks for Dublin is the large storage reservoir on the Varttry, at Roundwood, 24½ miles from Dublin. The embankment, which is an earthen one, with a puddle wall in the centre in the usual way, is 2000 ft. long, 28 ft. wide at the top, 66 ft. high, and contains 320,000 cubic yards of materials. The reservoir will have a water surface of 409 acres, will be 60 ft. deep at the embankment, and will contain 2400 million gallons, or 384,000,000 cubic feet. The top water level is 692 ft. above the sea. The gathering ground is principally mica slate, and is the same geologically as that surrounding Loch Katrine. The water is to be filtered near the reservoir, and after passing through a tunnel 2½ miles long through very hard rock, and for the construction of which twenty-one shafts had to be sunk, it is conveyed for about 17½ miles by a cast-iron pipe, 33 in. diameter, to receiving reservoirs, capable of containing ten days' supply at Stillorgan, 5 miles from Dublin, from which it is led to the town by two lines of pipes, each 27 in. diameter. The works will supply about 12,000,000 gallons a day, and they have been executed at a cost of a little over 500,000*l*.

Conclusion.

I have endeavoured to indicate some of the many substantial advances that have been made by our engineers since the institution was first founded, and to enumerate a few of the large undertakings which have been or are being brought to a successful completion; but I know that many more, and probably many more important subjects, will present themselves to the minds of members of the institution. From the comparatively limited extent of our coal-fields, and the certainty that coal will ultimately become costly to get, the economy of fuel in the steam engine and in the arts and manufactures will in future years be forced upon the attention of engineers, and a variety of new applications and combinations will be demanded for this purpose. The fact that good steel can now be produced at a cheap rate will also tend to modify many of our existing machines and tools, and the process of Bessemer, itself a great means of saving fuel, may yet change the dimensions of every iron structure. Vast railway works are still wanted in Europe, in India, and throughout the whole world; and as the importance of great Europe and Asiatic main trunk lines develop themselves, the magnitude of the undertakings and the dimensions of the works will increase, and greater skill will be continually called for, for the great iron horse must yet force its way over both the Balkan and the Bosphorus. New problems in naval architecture are continually presenting themselves, both for war and commerce. Our rivers must be purified at whatever cost short of crippling the manufactures that give life and wealth to the country. In waterworks we seem to be upon the threshold of greater works than were ever attempted by any nation or at any time. London is looking to South Wales, at a distance of 183 miles, for 220,000,000 gallons a day, at a cost of 8,000,000*l* or 10,000,000*l*, to supplement or supersede its supply from the Thames; and Liverpool to Bala Lake, in North Wales, a distance of 78 miles, for 60,000,000 gallons a day. In this country we do not experience the evils of a deficient or irregular rainfall, or the barrenness of a soil continually parched by a burning sun, neither do we know the extraordinary fertility and productiveness of the soil of some countries, when water can be obtained for irrigation. In Spain, in Algeria, in Australia, and in India irrigation works are only in their infancy. To these and to similar questions, which are continually becoming more complex and more extensive, requiring increased knowledge and study, must the future attention of engineers be directed. It is through institutions such as this, and the means they afford to their members of becoming acquainted with all that is new in theory or practice, and the incentives they present to emulation, that the engineers of this country have, unaided, been hitherto able to cope with and surpass those of any other nation; and that this institution may fulfil the high objects for which it was founded, and the duties it has to perform to the engineers of Scotland, we must be careful that it advances with the requirements of the age, and see that no obstacles are presented to its embracing engineering students of all classes, and particularly those young men to whom the country looks forward to perpetuate its good name for mechanics and engineering, and to support its place among the empires of the world.

BOILER EXPLOSION NEAR BRADFORD.—On Wednesday morning last, a boiler explosion, which occasioned the death of two men, occurred at the Trees farm, in the occupation of Mr. Thomas Ambler, at Manningham, near Bradford. The engine and boiler, of 4 horse power, were portable, and were used to work a thrashing-machine. They had been used every season since 1860, and several times during the present season. Prior to being worked on Wednesday last, they were examined by an engineer and mechanic, and pronounced to be in perfect and safe condition.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Clyde Shipbuilding for October.—The condition of this local trade, both present and prospective, is undoubtedly more hopeful than it has been for some months. In some cases the employers are cleared out of work, in others the yards are full; but, of course, the latter are rare exceptions. On the first of this month there were on the stocks, from Glasgow down to Greenock, about sixty vessels in the thirty building yards, thus giving an average of two to each. The number and tonnage of vessels launched on the Clyde during the month and ten months ending 31st October, as contrasted with the corresponding periods during the two preceding years, show a great falling off in point of numbers. As to tonnage, this year has been fully equal to last, but it is about 30,000 tons less than during the ten months of 1865, and fully 51,000 tons less than during the ten months of 1864. The following are the numbers and tonnage:

		Vessels.	Tons.
Month ending 31st Oct., 1867	...	13	10,000
" " " 1866	...	19	10,900
" " " 1865	...	25	13,650
Ten months " 1867	...	155	98,600
" " " 1866	...	182	97,750
" " " 1865	...	218	127,200

The following vessels were launched during the past month:

Owners and Destinations.	Builders.	Ton-nage.	H.P.	Character.	Name.
North German Lloyd's. Bremer and Baltimore.	Caird and Co.	2120	800	Screw	Berlin
J. A. Dunkerly and Co., Hull. Baltic trade.	Lond. and Glas. Eng. and Shipbuilding Co.	1500	150	"	Nyanza
Belfast Steamship Company. Belfast and Liverpool trade.	McNab and Co.	750	170	"	Voltaic
Parguay river and coasting trade.	R. Duncan and Co.	570	180	Twin-screw	Tigre
Pacana Steam Navigation Co. So. American coasting trade.	Aitken and Mansel	550	200	"	Goya
John McDonald, Glasgow. Coasting trade.	Donald and Macfarlane	100	25	Screw	Atlas
Catto and Sons, Aberdeen. China trade.	Stephen and Sons	1050	0	Composite	Forward Ho
J. Skinner and Co., Glasgow and Asiatic Shipping Company. East India trade.	Connell and Co.	920	0	"	Kinfauns Castle
John Kerr, Greenock. East India trade.	Macmillan and Sons	780	0	"	Barbadian
Donaldson Brothers, Glasgow. South American trade.	Dobie and Co.	680	0	Iron barque	Innucina
Captain Bello and others, Glasgow. Valparaiso trade.	L. Hill and Co.	600	0	Iron	Estrella de Chile
Walter Grievie, Greenock. Newfoundland trade.	R. Steele and Co.	200	0	Composite	Douro

Other Shipbuilding News.—Messrs. Caird and Co., Greenock, have just concluded a contract to build a large screw steamer for the Hamburg and American Steamship Company, similar in every respect to the large vessel at present in a state of forwardness in their yard.

Messrs. Robertson and Co., shipbuilders, Cartdyke, Greenock, have just completed a contract to build a fine saloon paddle steamer for Rio Grande do Sul. She is to the order of John G. Kincaid, Esq., late of Greenock, who has had a number of steam vessels built in this country for South America. The new vessel will be built under the superintendence of Captain Kincaid, Corriebank, and will be propelled by a pair of oscillating engines, and fitted up for passenger and cargo accommodation, and generally somewhat similar to the Cuyaba, which was built by this firm, and despatched last month. Messrs. Robertson are in treaty for the building of several other large vessels, so that this firm is likely to have a busy winter.

There was launched, last week, by the London and Glasgow

Engineering and Iron Shipbuilding Company (Limited), the Nyanza, an iron screw-steamer, built to the order of Messrs. J. A. Dunkerly and Co., of Hull, of the following dimensions, viz., 260 ft. by 33 ft. by 25 ft. to spar deck. The vessel is to be fitted by her builders with direct-acting engines of 150 horse power, combining all the most modern improvements, both in ship and machinery.

The Diamond, a small iron screw steamer of about 100 tons, was launched from the building-yard of Messrs. J. and R. Swan, Kelvindock, on Thursday last. The Diamond is intended for the coasting trade.

The Dacca, a fine steamer, recently launched by Messrs. A. and J. Inglis, Glasgow, for the British India Steam Navigation Company, went down the river on her official trial trip on Thursday last. The vessel, loaded with coals and cargo for the passage to Calcutta, drawing 19 ft. aft and 17 ft. 4 in. forward, attained a speed of 12 knots per hour, on the measured distance between the Cloch and Cumbræ. The principal dimensions of the Dacca are 276 ft. by 34 ft. by 19 ft., with accommodation on the main deck for 120 first-class passengers. The vessel is fitted with a pair of direct-acting surface-condensing engines of 300 horse power nominal, embracing all the latest improvements for economising fuel. The Dacca will be commanded by Captain Day.

The Glasgow Pig Iron Market.—Since my last report prices have undergone some little change in a downward direction. The nominal price on Friday last was 55s. 3d. cash, but the latest quotation, that of this afternoon, is from 54s. 9d. to 55s. The stock in Messrs. Connal and Company's yard is 210,435 tons, with warrants circulating for 196,500 tons, and in canal yard 16,989 tons, with warrants for 14,800 tons. The pig iron shipments from all Scotch ports for the week ending 2nd October, 1867, were:

	tons.
This year	9,278
Last year	14,372
Decrease	5,094
Total since 25th December 1866	536,855
For corresponding period in 1865-66	508,502
Increase	27,853

Glasgow Customs' Revenue.—The customs' revenue of the port of Glasgow for the past month shows a remarkable increase over the corresponding month of previous years, and is the highest sum drawn in one month, and within 13,700*l* of the revenue of Greenock, which two years ago yielded about a half more than Glasgow. The following are the sums:

Month ending 30th Oct., 1867	£124,242
" " " 1866	98,443
" " " 1865	78,264

being an increase of 30,800*l*. over October, 1866, and 51,000*l*. over October, 1865.

The revenue from river dues is also increasing with great rapidity, notwithstanding the extraordinary dullness of the period through which we are passing. In October, 1866, the harbour revenue was 10,497*l*. 3s. 5d., and in October, 1867, it has risen to 12,111*l*. 0s. 5d., giving an increase on the month of 1618*l*. 17s., or a total increase of 4800*l*. for the four months since 30th June, 1867.

Greenock Customs' Revenue.—The revenue of the port of Greenock for the month and ten months ending October 31, as compared with corresponding periods in two preceding years, are as follows:

	£	s.	d.
Month ended 31st Oct., 1867	137,916	14	10
" " " 1866	112,674	14	8
" " " 1865	120,250	1	8
Ten months " 1867	1,239,563	0	0
" " " 1866	1,176,765	0	0
" " " 1865	1,047,639	0	0

The New Hutchesontown Bridge.—A final decision has now been come to by the Bridge Trustees regarding the new Hutchesontown Bridge. The estimates were generally so very much above the Parliamentary estimate, that the engineers, Messrs. Bell and Miller, were instructed to reduce the cost as nearly as possible to that estimate. The modifications that have been suggested by them are such that the lowest tender, which was formerly 54,000*l*, has been reduced to 48,900*l*. Even this exceeds the Parliamentary estimate. The abutments will be raised on cylinders, not on piles, as some of the economical members of the trust suggested; but the engineers have consented to reduce the number of cylinders from sixteen to twelve, believing that the stability of the bridge will be in no way affected by the change in the plans. In order to effect a further saving, it was suggested that freestone should be used instead of granite; but granite ultimately carried the day. The bridge proper will be of iron, and will be a very handsome structure. Messrs. Kanna, Donald, and Wilson, engineers, Abbey Works, Paisley, have obtained the contract. This is the largest contract of the kind ever undertaken in Paisley.

THE PACIFIC RAILWAY.

A CORRESPONDENT of a New York paper gives the following account of the construction of the Pacific Railway across the vast plains of Western America—a line which will open railway communication between New York on the Atlantic and Sacramento on the Pacific (or rather on a bay opening from it), a distance of 3400 miles.

The Union Pacific has already completed nearly five hundred miles west, commencing at Omaha, and the Central Pacific is in running order more than a hundred miles east of Sacramento. They will unite somewhere about Salt Lake City.

The work of track-laying is divided into three parts—the tie-laying, sleeper-laying, the track-laying proper, and the bolting and spiking.

First come the engineers, who fix the line of the ties (sleepers), determining where they are to go; next a set of skilful workmen, who put down a few ties at the proper level, enough to determine the position of the rest of the ties, and finally the great body of the layers, who fix the remaining ties on the level of

those already down—workmen follow, throwing in dirt and ramming it down, and all is then ready for the track-layers. These are a gang of ten stalwart fellows, in whose work is the great attraction. Taking an open truck of a car, they run it back to where the rails were dumped off of the supply train, and load it with rails and the proper number of joints and spikes. A couple of horses are then hitched to the car, and haul it to the end of the track, when they are unhitched, and sent back for another load, leaving in their place a small but intelligent horse that performs his work with great steadiness and zeal.

The truck being at the end of the track, and the wheels blocked, at a word from the foreman five men on each side seize a rail and pull it out over the front of the car to its full length. "Down," sings out the foreman, and down come two rails into their proper places on the ties. In an instant the man at the farther end has applied a measure and adjusted the width, the man next the car has whipped out the blocks, the little horse knows that now it is his turn, and strains and pulls, and the car runs over 9 yards more of the Union Pacific Railroad. "Whoa up!" the horse stops, the wheels are blocked, again two more rails are seized, "Down," cries the foreman again, and down come 9 yards more. It is very exciting to watch this work, but you can't keep still. Every fifteen seconds the voice of the foreman rings out sonorous "Down," and every fifteen seconds another set of rails respond with heavy clang. Occasionally a rail comes out that is not perfectly straight. In this case, instead of putting it down, one end is rested on the truck, all the men steady it, and a mighty Hercules, seizing a tremendous sledge-hammer, deals it such blows as soon reduce it to its normal line.

Nine yards in fifteen seconds! Great Heavens! what a pace! This is thirty-six yards a minute; nearly a mile and a quarter an hour. At this rate counting ten hours a day for work, and estimating the distance to Sacramento at one thousand six hundred miles, the work would be done in a little more than four months. But follow the truck along, and you will see why it is that this pace is not kept up, and why two miles a day is about an average of the work. A truck carries thirty rails. It exhausts its load, then, after dropping fifteen sets of rails, and must go back for another. This is what takes time, for the rails are heavy and slow to be loaded, and the truck must be run back to the point where they were unloaded from the supply-train. As the truck advances, this point recedes, and the truck must be run further and further back each time until a new load can be dumped off nearer.

This and many other difficulties reduce the track laying to an average of about two miles a day. In September, owing to the want of bolts and spikes, only ten miles of track were laid. The most constant forethought and the greatest energy are necessary to keep always ready rails enough, and bolts enough, and spikes enough, and the thousand and one articles, the want of any one of which would stop the work. And indeed, considering that the iron comes from all over the country, much of it from New England, that the ties are brought from wherever they can be got, many from Michigan, Minnesota, and Wisconsin, that everything must be transported by a single line of track to Council Bluffs, thence across the uncertain Missouri river in boats, and again five hundred miles to their destination, and that the daily consumption of rails alone for two miles' progress is two hundred tons, and of ties five thousand two hundred and eighty, and of everything else in proportion—considering all this the wonder is not that the progress is not greater, but that it is as great as it is.

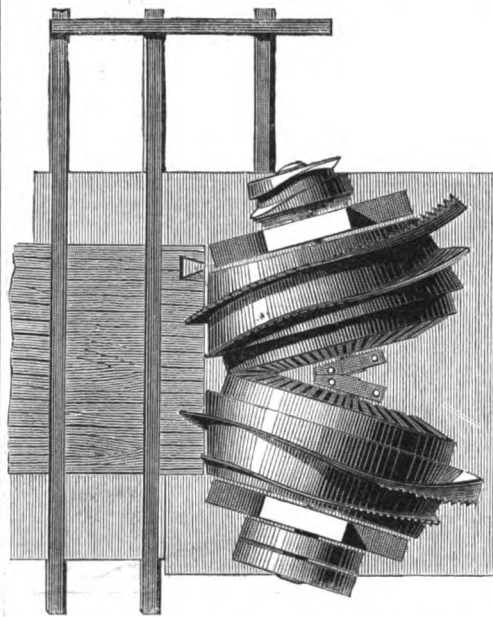
The track laying only leaves the rails in their places, resting there by their own weight. Close behind the truck from which the rails are laid come two men, who place at each jointing of the rail a clamp, and at each sleeper two spikes. These clamps, called the fish clamps, consist of two pieces of strap iron, which are placed lengthwise of the rail and in the hollow of it, and are bolted together by bolts passing through them and both rails. The rails are thus securely fastened together, and form one continuous piece of iron. Close behind the clamps come the spikers, who put in enough spikes to hold the rails in their proper position until the main body of spikers come up, when the exact width of the rails is fixed, the sleepers finally settled, and the last spikes driven home—and the work is done. This is the main work, but a dozen branches of it are going on all at the same time. Fifty mule teams are constantly hauling up sleepers, water-carts are making constant trips to supply the whole establishment with water. Bridge men, three or four miles ahead, must permit no delay from bridges, and the telegraph must be the *fidus Achates* of the railroad. Every twenty miles a water tank is to be constructed, and wood, wherever it can be got, must be cut up and hauled for the engines.

The Rocky Mountains are now in sight. Thirty miles further and Cheyenne will be reached, and it is hoped the Black Hills this fall. The winter will then set in so as to prevent further work this year. But next year, when spring opens, it will again go on, and with renewed energy. General Dodge, the chief engineer of the road, who has just returned from a six months' exploration of the mountains, reports finding an easier grade and an abundance of excellent coal.

AMERICAN DOVETAILING MACHINE.

ONE of the last additions to the Paris Exhibition, which is now a thing of the past, was a very ingenious dovetailing machine in the American department. The machine was mounted on a neat rectangular frame, carried on four cast-iron standards, having at its further extremity brackets carrying the main or driving shaft, and the discs which carry the helical saws, and on its front side guides for the movable table which carries the piece of wood to be dovetailed. This table is moved longitudinally by means of a screw about 1 in. pitch, having one of its sides conical to increase the bearing, working into a segment of a nut on the underside of the table. By means of a handle conveniently placed at the side of the table, this segmental nut can be thrown in and out of gear; but, in addition, there is a screw with about $\frac{1}{2}$ in. pitch, working in the under part of the table, and giving every facility for the accurate adjustment of the piece of wood to be operated upon after the segmental nut has been put in gear with the main screw. The motion for the screw is derived from the main shaft by means of a pinion

driving a wheel loose on its axis, and so arranged as to communicate the necessary speed to a pinion on the screw-shaft. The main shaft has on it a fast and loose pulley, the pinion above mentioned, and a bevil-wheel driving another loose on its spindle, thereby communicating motion to a bevil-wheel on the outside of one of the discs carrying the saws. There are two discs mounted on axes inclined to each other, as well as to the main driving-shaft, and revolving at the same speed, the one being inclined to the right and the other to the left, the motion being transmitted from the first to the second disc by means of bevil-wheels cast on their inner surfaces. Each disc has on its outer circumference a spiral groove making one complete turn, into which is fitted a saw composed of segments, so arranged as in one complete revolution to give both the longitudinal and transverse cut necessary to finish a dovetail, one half being made by one disc and the other half by the other. The leading portion of the saw is composed of segments similar to those that could be cut from an ordinary fine-pitched circular saw, whilst to produce the transverse cut after the longitudinal one is finished, the segments assume the form shown in the accompanying engravings, from an inspection of which the arrangement will be readily understood.



These segments are held in their place by means of cast-iron cheek plates, held on by set screws with square heads, and in about one minute the attendant on the machine could change all the segments and replace them by others having a finer or coarser pitch of teeth, if desired. To prevent the saws from splintering the wood on its under side, a longitudinal shallow cut is made by a knife-edge at the bottom of the dovetail before the helical saws operate on the wood; this is a most important point, and without it good work cannot be produced. At the back of the machine a small horizontal shaft carries two pinions, which gear into quadrantal wheels fixed on the main spindle, which cause the bearings of the discs to revolve, and so, consequently, the discs with their saws revolve through a quadrant, giving the facility for cutting the counterpart to the dovetail. An arrangement is also provided for raising the table so that the dovetailing can be done on the bevil, if desired. The attendant all day long was besieged by crowds anxious to see this machine at work, and certainly he showed great patience in altering his machine to convince the sceptical of its wonderful scope and accuracy. The machine is patented by Mr. Armstrong, of New York, and already the English patent has been sold to Messrs. Robinson and Son, of Rochdale, near Manchester, the French one to Messrs. Martin, Son and Co., of Rouen, and the German one to Messrs. Richard Hartmann and Co., of Chemnitz, Saxony. The machine was introduced into Europe, and the sale of the English and Continental patents effected, by the European Inventors' Agency and Exchange Company.

THE LONDON WATER SUPPLY.

TO THE EDITOR OF ENGINEERING.

SIR,—This question, which has occupied local attention almost uninterruptedly during the last fifteen years, and which keeps turning up ever and anon in as unwelcome a manner as a tax-gatherer or a doctor's bill, is again before the public in the shape of a correspondence between the East London Waterworks Company and the Board of Trade, both on the subject of quantitative and qualitative supply, arising out of an inquiry occasioned by a memorial to that body from some of the consumers of the company's water. This correspondence has elicited from your potent contemporary, *The Times*, one of those articles which, as dealing with technical subjects, are none the less interesting because they are not exhaustive, or none the less useful because they do not remove the evil on which they discourse.

It seems to be admitted by that company that there has been a deficiency of supply on various occasions, but while expressing a desire to supply the wants of their customers "they decline to be constituted into a water police." They also admit that on some rare occasions they have drawn limited quantities of unfiltered water from open ponds into which sewage matter had been known to percolate; but Captain Tyler, the Board of Trade surveyor, is able to report that the company have done all that could be expected of them to prevent sewage from the river Lea soaking through into their reservoirs.

It is well known, however, that this company draw their supplies of water chiefly from the river Lea, and as it is also stated that the course of the river above their works is beyond

their direct control, I doubt whether the consumers of the company's water will be able to share in the satisfaction which Captain Tyler may have felt in being able to report as above quoted.

To the question of the prevalence of cholera in the district supplied by that company, which has crept into that correspondence, I attach less importance (as affecting this water question) than the memorialists to the Board of Trade seem to have done; for not only does that district lie very low and is badly drained, but its population is decidedly the poorest of the whole metropolitan community, its dwelling-houses of indifferent construction, badly ventilated, and generally overcrowded. Here, therefore, are elements sufficient for the development of choleraic disease without attributing it wholesale to the quality of the water or to the want of it.

The question which the article in the *Times* has suggested to my mind, however, is, whether the east end is really any worse off in the matter of water than the west, which draws its supplies from the Thames, and the following extract from the report of the River Commissioners I think will show that there is ample reason for entertaining that question. I there read that

"Oxford, Windsor, Reading, Kingston, Richmond, and other places contribute the steady daily flow of the sewage of a population of 180,000 persons to the contents of the river above the pumping-stations of the metropolitan water supply. Mr. Clark, of Reading, tells us that he has seen as many as fifteen or twenty dead dogs, cats, pigs, and sheep, besides filth from the manufactories, from the hospital, and from the jail, coming into the water supply from the Kennet; that from just above Reading to where this tributary enters the Thames, it is in a deplorably filthy state, and that the bottom of this part of the stream is so saturated with gas-tar that a fishing line becomes coated with it, and a cane thrust to the bottom would get an inch or two of gas-tar and mud. The Cherwell and the Isis are contaminating the Thames to an enormous extent. In fact, but for the peculiar propensity of water to deposit its mechanical pollutions in its course, and thus to run itself clear even when lining its bed with a pestiferous mud that is offensive if stirred up, the water of the Thames where pumped up for the supply of the metropolis, would be as offensive as that which was daily to be seen between the bridges before the opening of the new metropolitan drainage."

I doubt whether a worse picture than this could be drawn of the state of the water of the river Lea; and as there is every reason to believe that the companies drawing from the Thames are equally unwilling to be constituted a water police with that drawing from the Lea, it seems not only reasonable to express a wish, but it is quite imperative that a body of this description should be constituted, as has been done already for the execution of other public works of like importance—I refer, namely, to the Metropolitan Board of Works.

This question of the metropolitan water supply, however, has long since been taken out of the exclusive hands of the ordinary journalist, and has been seriously dealt with by some of the most eminent professional men of the day. Singularly enough, the *Times*, in its concluding paragraph, throws out a number of hints, each of which has received separate consideration.

Some of the schemes that have been advocated, it is true, appear rather chimerical by reason of their magnitude. Such, for instance, is the one propounded by Messrs. Hemans and Hassard, who wish to supply not only London, but also some of the large towns, which could be conveniently reached along the line of their proposed aqueduct, as though the supply of London was not a problem of sufficient magnitude of itself, and others leave the question of purity of supply entirely entangled in the cobwebs of hypothesis; as, for instance, the scheme of Mr. Telford Macneil, who proposes to take the waters of the Thames, such as they are at Teddington Weir, and spread them over the Bagshot sands in Surrey, there to undergo a system of natural filtration, trusting to Providence that His natural filter shall remain efficient for ever without renewal.

Two of these schemes, however, are well deserving of fair consideration, namely, the one propounded by Mr. Remington, proposing to fetch the water in Derbyshire from the sources of the river Dove. The general outlines of this scheme were published, and very favourably commented on by you, some months ago. The other scheme is the one advocated by Mr. Bateman, who proposes to supply the metropolis with water from the sources of the Severn, in North Wales.

The independent position which this gentleman has made for himself makes his voice in this matter deserving of special attention, while his great experience in this particular branch of engineering renders him especially qualified to grapple with this question. The pamphlet, which he published two years ago, shows that he has thoroughly studied it, not only in its technical, but also in its financial bearings; and the great success of the Glasgow Waterworks carried out by him cannot fail to command confidence.

I would, however, not be understood to advocate the scheme of any particular individual, but, through your columns, to call the attention of the influential portion of your readers to this important subject.

I remain yours very truly,

October 31st, 1867.

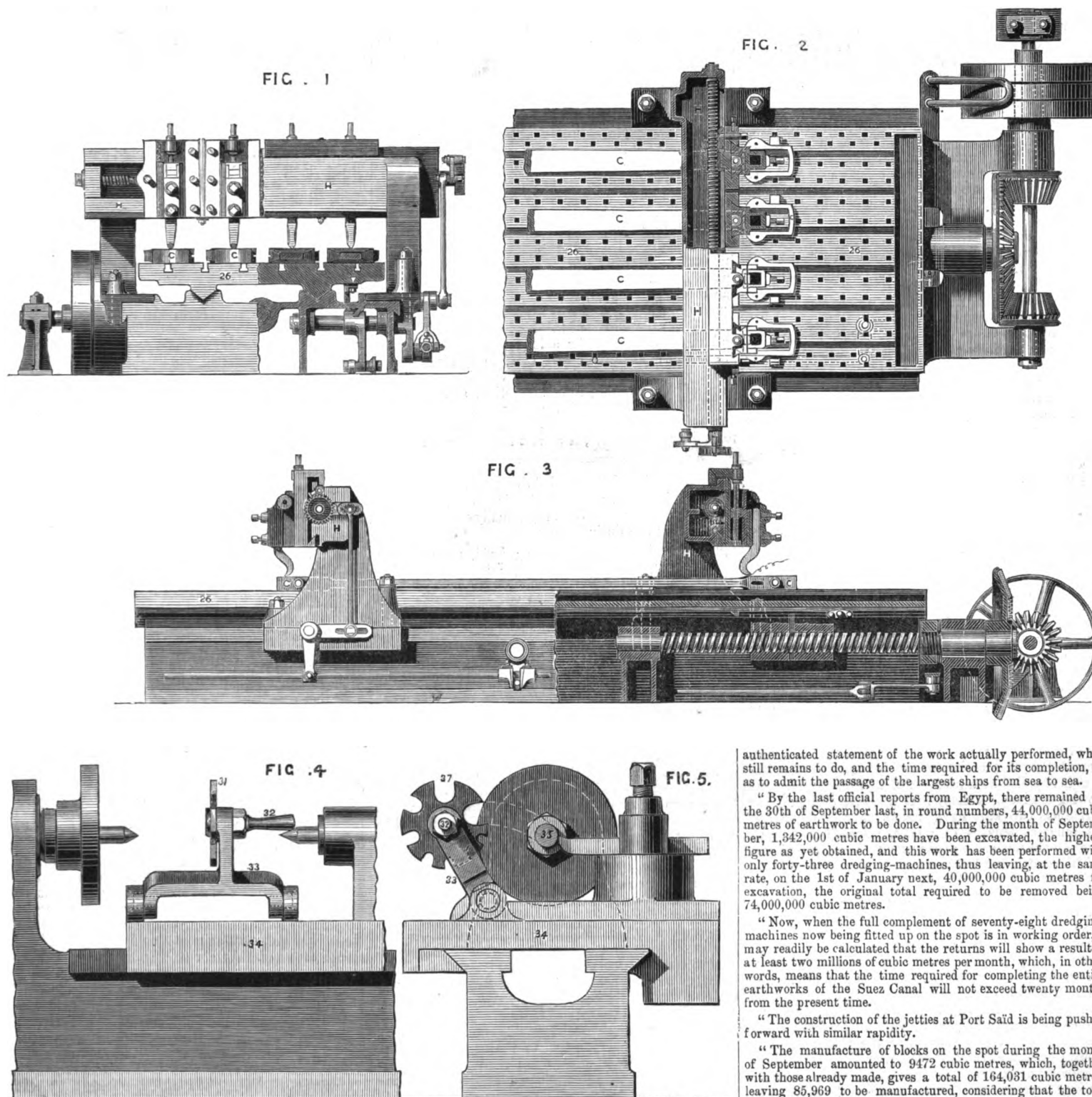
J. J. BIRCKEL.

FALMOUTH DOCKS.—A special meeting of the Falmouth Docks Company was held a few days ago to consider the advisability of handing over the concern to the Public Works Loan Commissioners, in consequence of the inability of the directors to find money for carrying out the undertaking. After considerable discussion, it was resolved, by a large majority, that the course adopted by the directors in asking the Public Works Loan Commissioners to take possession of the undertaking and to make advances during their possession for the repair, security, and completion of the works was the best for the interest of all parties concerned, and was approved by the meeting. The works had for some time been in a critical condition from the damage sustained during the last winter, and no further funds could be raised.

SEVILLE, XERES, AND CADIZ RAILWAY.—As wooden sleepers are found to wear out very rapidly upon this line, the directors appear inclined to employ iron ones after the example of the Madrid, Saragossa, and Alicante Company. The rails which are worn out are being replaced by heavier ones.

MACHINE FOR PLANING THE COUPLING-RODS OF LOCOMOTIVE ENGINES, &c.

DESIGNED BY MR. STEPHEN ALLEY, ENGINEER, GLASGOW.



WE, last week, illustrated some machine tools, designed by Mr. Stephen Alley, of the firm of Messrs. Neilson Brothers, of Glasgow, for finishing the details of locomotive engines, and we now give engravings of another of these tools, together with a kind of gauge applicable to lathes or other machines. In the annexed engravings, Figs. 1, 2, and 3 represent a machine for planing the ends of locomotive coupling or connecting rods, and Figs. 4 and 5 the gauge above referred to.

The machine shown by Figs. 1, 2, and 3 is in many respects like an ordinary planing-machine, but it is furnished with two tool-heads, H H, one or both of these being adjustable. The cutting tools, T, of the two heads face opposite ways, those on one head operating on one end of the coupling-rods, C, when the table, 26, moves in one direction, and those on the other head acting on the opposite ends of the rods during the return traverse. It will be seen from the figures that several rods may be planed simultaneously. The traversing, feeding, and reversing motions are arranged very much as in ordinary machines, but the length of traverse provided for is much shorter.

The gauge represented in Figs. 4 and 5 is shown as applied

to an ordinary lathe. The gauge itself, 31, consists of a steel disc, in the circumference of which are formed indentations of various sizes. The disc is carried by the centre pin, 32, this pin being supported on the link, 33, which vibrates on studs carried by the slide, 34, and the gauge can thus be readily brought to bear upon any article, 35, which may be in the lathe. This arrangement of gauge is convenient in many respects, and being attached to the arm or link, 33, it is always at hand when wanted. It is, of course, capable of being applied to various other machines besides lathes.

THE SUEZ CANAL.

MR. DANIEL A. LANGE, the English representative and director of the Suez Canal Company, has addressed to the *Times* the following letter on the present state of the canal works. He says:

"In a recent article in the *Times* on the subject of the Suez Canal, you were good enough to express the opinion, 'that the Suez Canal may be finished is what we all wish, but what few, if any, of us can even now confidently assert.'

"I, therefore, beg to submit to your readers a brief but

authenticated statement of the work actually performed, what still remains to do, and the time required for its completion, so as to admit the passage of the largest ships from sea to sea.

"By the last official reports from Egypt, there remained on the 30th of September last, in round numbers, 44,000,000 cubic metres of earthwork to be done. During the month of September, 1,342,000 cubic metres have been excavated, the highest figure as yet obtained, and this work has been performed with only forty-three dredging-machines, thus leaving, at the same rate, on the 1st of January next, 40,000,000 cubic metres for excavation, the original total required to be removed being 74,000,000 cubic metres.

"Now, when the full complement of seventy-eight dredging-machines now being fitted up on the spot is in working order, it may readily be calculated that the returns will show a result of at least two millions of cubic metres per month, which, in other words, means that the time required for completing the entire earthworks of the Suez Canal will not exceed twenty months from the present time.

"The construction of the jetties at Port Saïd is being pushed forward with similar rapidity.

"The manufacture of blocks on the spot during the month of September amounted to 9472 cubic metres, which, together with those already made, gives a total of 164,031 cubic metres, leaving 85,969 to be manufactured, considering that the total originally required for the completion of both the jetties was 250,000 cubic metres.

"The entire quantity already sunk in the sea at the end of September amounted to 142,775 cubic metres; remained to be immersed, 107,224 cubic metres: total, 250,000 cubic metres for both jetties.

"Now, the fact should not be overlooked that the construction of the jetties is progressing even more satisfactorily than we anticipated. According to agreement, the contractor was bound to sink 6000 cubic metres per month, and during the last month 7255 cubic metres were immersed, thus exceeding by 1255 cubic metres the quantity required according to contract with the company. These returns will go on increasing instead of diminishing; but, taking even 6000 cubic metres per month, it will be seen that both the jetties will be completed in eighteen months from the present time. It may not be out of place to mention that these so-called blocks weigh about 20 tons each.

"Having said thus much on the subject of the progress of the Suez Canal works, I trust I may be permitted to add that the time is near at hand when these gigantic works will be completed for the benefit of all nations, and to express a hope that your sympathy for our great work will grow in proportion to our success."

THE GOVAN IRONWORKS, GLASGOW.

THIS establishment is one of the oldest and most generally known ironworks in Scotland. It is historically connected with the hot blast, the water tuiere, the Condie steam-hammer, and the earliest stages of the Bessemer process, and in its present condition it is rather a specimen of the standard character of the past than an example of modern and progressing practice in the manufacture of pigs and of malleable iron. The works are laid out on a large scale. They comprise a row of six furnaces, of which, however, only five are complete at the present time, and only two are kept in blast. To these are added three coke refineries, for making refined metal for puddling. The forges and rolling-mills, which form a separate enclosure, contain about forty puddling-furnaces with their accessory steam-hammers and mills, a very extensive arrangement of bar-mills for merchant iron of different sections, and a large plate-mill for boiler and ship plates. The Govan Ironworks are connected by railway with the collieries belonging to Mr. Dixon, and with the Calder Ironworks, which latter furnish a very considerable quantity of refined metal to the Govan Ironworks for the supply of their puddling-furnaces.

The blast furnaces are about 60 ft. high, open topped, and working with hot blast. The stoves are arranged below the ground level at the sides of each furnace, so as not to interfere with the accessibility of the latter from all sides. The stoves are of the pisto- pipe form, and are fired with coal slack, about 7 cwt. of coal slack being required per ton of iron made. The make of each furnace is from 12 tons to 15 tons of pig iron at one cast, the furnaces being tapped every twelve hours. The iron produced is mostly grey, the iron required for puddling being by preference passed through a preparatory refining process, in which the graphitic carbon is removed from it. The ores employed form a mixture of a very heterogeneous character. The principal quantities are Scotch blackbands and claybands, both calcined and charged in about equal proportions. To these are added about 20 per cent. of red hematite ores, and a mixture of Irish and Scotch limestones, the hematite and limestone being charged in the raw state, without being previously burnt or calcined. The coal is used raw, as in most other Scotch ironworks, and the charges are made up in loads of 15 cwt. of ore and limestone for every load of 10 cwt. of coal. Taking the metallic contents of the ore in this mixture, the consumption of coal in the furnace may be estimated at about 50 cwt. of coal per ton of iron made, which is very near the average of present Scotch practice in making grey iron. The blast is supplied at a pressure of $2\frac{1}{2}$ lb. by a very fine blowing-engine of a somewhat unusual design. The engine has two blowing cylinders of equal diameters, but unequal lengths of stroke, placed behind each other on the same side of the rocking beam, one piston-rod being attached to the end and the other at half the radius of the beam. At the opposite side, the steam cylinder stands at full radius, and midway between it and the main centre is the crank and fly-wheel, worked by a connecting-rod attached to the beam. The blowing-engine is supplied with steam by seven double-flued Cornish boilers, fired with coal slack and placed below the ground level close to the engine-house. The hoist consists of a pitched chain running over drums of polygonal form, and the wagons containing the charges are attached to pairs of projecting pins placed at equal distances upon the chain. The refineries consist of rectangular hearths each carrying a cylindrical open funnel, and provided with the usual inclined tuyeres, cooled by a current of water. The charge of grey iron for each refinery is 24 cwt., and six or seven charges are made per day. The refined iron is run out upon a rectangular bed, and cooled by water. The fuel employed for this purpose is coke of ordinary quality. The puddling-furnaces are charged with refined metal and grey iron mixed in different proportions, according to the qualities of wrought iron required. The time of puddling is shortened by a greater percentage of refined metal, and is usually $1\frac{1}{4}$ hours for each charge of 4 cwt. This gives a production of 28 cwt., or seven heats per day of 10 hours in each furnace. The practice of weighing the iron with "long" and "short" weight, to allow for waste in puddling, which originated in Staffordshire, is still in use at these works. The pig iron is weighed at the rate of 120 lb. to the "hundredweight," and the mill bar hundredweight has only 112 lb. It is considered that an average good hand will produce full weight of puddled iron from a mixture of refined ore and pig iron in equal quantities, and this would correspond to a waste of 7 per cent. only, and from pure refined

metal a skilful puddler can obtain a still more economical result. It is obvious, however, that the grey iron, and particularly the contents of silicium in the latter, will play a very important part in these figures, and that the puddlers are, therefore, extremely attentive, and even prejudiced, as far as brands of iron are concerned. The fuel used for puddling is large coal, as usual, but we understand that a Siemens gas furnace has been recently put down in these works for the purpose of experiment. The steam-hammers are mostly made on Condie's patent plan, but they are of moderate sizes, their only use being for shingling puddle blooms. The rolling-mill engines are all vertical-beam engines, somewhat similar in their general appearance to those we illustrated in our previous volumes, in our descriptions of the Barrow Steel Works. The engines carry their fly-wheels on the second shaft, which runs at a higher speed than the crank-shaft of the engine proper, and this second shaft is geared to the mill, an arrangement which is with advantage discarded in more modern rolling-mills. In fact, unless there are several mills running at different speeds attached to the same steam-engine, all gearing can be dispensed with, and direct action of the engine upon the rolls is the most suitable system. There have been rolling-mills of this kind at work in England and on the Continent for a long time past; and they are very economical in first cost, in repairs, and in steam power. The bar-mills are all working with single pairs of rolls running in one direction, and the work is lifted over the top roll for returning, the plate-mill only being arranged with a reversing movement, which, for rolling large plates, is almost indispensable.

ALKALINE WORKS.

THERE is not much engineering involved in the different processes by which salt is gradually converted into soda, giving rise during the process to a considerable number of accessory products, such as soda-ash, bleaching-powder, and all the other substances which form the trade of a modern alkaline works. Still the wants and necessities of such chemical works have occasioned the execution of some of the most remarkable engineering feats in the shape of colossal chimneys, structures which in regard to height are equalled only by some very few of the most celebrated wonders of architecture existing. These chimneys were originally constructed with a view of carrying certain gaseous products, which could not be utilised in the works, up to a sufficient height into the atmosphere to prevent their immediate return to the surface of the ground in that state of concentration in which they would form a nuisance for the neighbourhood of the works. Chemical science in its progress has taught manufacturers step by step to use up many of the gases which they used to send up through these chimneys, and to convert them into marketable articles, either directly or indirectly by applying them to the production of other chemicals. The advantages of a large and powerful chimney have, however, proved sufficiently great in every respect to make these costly structures even now objects of high utility and value to a chemical works, and of a certain pride to their proprietors. In most other respects, however, a visit to a large chemical works in this country will, as a rule, convince an engineer that the interchange of ideas and the mutual assistance of engineering and chemical science have not been carried so far as might or ought to have been the case. Chemists in this country have very frequently made a reproach to the engineering profession that chemical science has been too much neglected by engineers, and while we fully endorse such a statement, it offers a very poor consolation to return it by saying that manufacturing chemists as a rule do not give sufficient attention to engineering science and practice. The structures in a chemical works do not always allow of the same elegance of design and quality of work and materials as are used under other circumstances, because the escape of gases, acids, and other chemicals acting violently upon many substances, and particularly upon metals—an escape which, in practice, can never be entirely avoided—prevents the possibility of applying the most usual modes of construction. This palpable reason has driven manufacturing chemists to the application of wooden structures, occasionally of great intricacy and want of durability, and, almost in all cases, defective in accommodation and in ventilation. Mechanical arrangements for transporting materials in the interior of the works are also much neglected, and hand-labour of the rudest kind, still dearly paid on account of the unpleasant and unhealthy nature of the occupation, is resorted to. The workmen, for instance, who are employed in the manufacture of bleaching-powder

suffer from the constant inhalation of chlorine gas, which escapes at every leak of the apparatus. This chlorine gas is made by exposing the brown oxide of manganese to the action of hydrochloric acid at an elevated temperature and in a closed vessel or still. The gas is then passed through pottery pipes over a quantity of slack lime, and in this operation a certain amount of leakage, which is considered unavoidable, causes the chlorine gas to escape into the still-house. Each workman is furnished with a quantity of wet flannel, which protects his respiratory organs to a certain extent, but not further than to make him lose the sense of smell after a short employment, besides creating a certain kind of cough and considerably shortening the average duration of life. Men not accustomed to the inhalation of this gas are entirely incapable of doing this class of work, although it requires no particular skill; and the wages of men who can keep to this employment are therefore as high as those of skilled men in other branches. The ventilation in these still-houses or buildings which contain the chlorine stills is, moreover, most imperfectly managed, even in some of the largest soda works in this country. The experience and teachings of General Morin about ventilation by a downward current seem to press themselves irresistibly upon the mind of every one who considers that chlorine is a very heavy gas, that the height of the stills, and particularly the position of many openings which are most likely to leak, are near the floor-level, and that the ascent of the gases through the whole height of the house should be prevented by all possible means. With the enormous chimneys at the disposal of every one of these establishments, artificial ventilation would appear to be a matter of comparatively small expense, and one dictated by humanity, if not by prudence. There are some other operations where the escape of noxious gases, although not quite as constant, is still extremely unpleasant during certain operations, such as removal of the products from the furnaces, &c., and in all these places a very wide field is open for improvements in the engineering arrangements of soda works as they at present exist. Such improvements of course require the intelligent attention of manufacturing chemists before they can be at all passed into the hands of the engineer; but this supposes that chemists should at least know *what* can be done even if they are not aware *how* it can be effected, by engineering practice. We do not know what may be the precise standard of technical education of manufacturing chemists in this country, and whether it stands in the same relation to that of other countries as that of some other branches. We have very recently heard it stated by the manager of an important branch of a large soda works in this country, that he neither knew nor cared to know the precise chemical composition of the material which he was operating upon, his business being "to make the stuff" (according to prescriptions prepared by a foreign chemist), and not to theorise about its composition. We do not of course desire to hold up the example of an exceptionally ignorant and thoughtless individual as in any way representing the generality of manufacturing chemists, but the fact that the existence of such an exception is even a possibility speaks for itself. As a rule, the notion is prevalent that improvements in mechanical arrangements have a comparatively trifling influence upon the total economy of a chemical works. This is most certainly erroneous. In a large factory many thousands of tons of materials are moved forwards and backwards over its extensive working area in the course of a year. It requires mechanical work in almost every stage of the different chemical operations carried out, and all this affords a space for the application of science and skill to an extent almost as great, as important, and as remunerative as many a purely chemical method for the recovery of some material previously wasted, or of a new application of valueless products, may have given, and are still likely to give.

QUALITY OF INDIAN COALS.

IN forming an estimate of the value of coal, and of the proportional quantities which various countries are likely to yield, a very essential consideration is the quality of the coals as determining their "duty," or amount of work done by similar quantities. At first, of course, before coals are worked to a sufficient extent to admit of this "duty" being tested by long-continued series of practical experiments, the only means of arriving at a satisfactory knowledge is by direct analysis or assay of the mineral. This plan is, however, always subject to error. The portion experimented upon is necessarily small, and it is scarcely possible to obtain in such small specimens a thoroughly

fair representative of the general quality of a bed; and, further, this quality will itself vary, and that very materially, in different parts of the same layer. Still, taking care to select, not picked, but fair average specimens, and combining several of these, it is possible to obtain truly comparable results by assay. The following list gives the results of assays made at various times in the Geological Survey Office, showing the relative amounts of fixed carbon, of volatile matter, and of ash for eighty different varieties of Indian coals:

No.	Localities.	Fixed carbon.	Volatile matter.	Ash.
1	Kurhumbali Field.			
2	Mollichooan ...	64.9	24.8	10.3
3	Do. ...	68.6	24.8	6.6
4	Do. ...	73.1	22.1	4.8
5	Passarabhaya ...	68.5	19.0	12.5
6	Boreadeh ...	66.3	23.0	10.7
7	Choonjhoonkee ...	67.2	24.0	8.8
8	Jutkutti ...	50.9	15.1	34.0
9	Do. ...	48.2	12.6	39.2
10	Khandia Hill ...	57.1	16.4	26.5
11	Rajmahal Hills.			
12	Mussinia ...	57.60	34.40	8.0
13	Do. ...	48.80	30.40	20.80
14	Panchbini ...	44.2	34.1	21.70
15	Goomoo ...	36.00	45.60	18.40
16	Chilgo ...	45.50	43.5	11.0
17	Oormoo ...	45.00	44.6	10.40
18	Do. ...	45.30	35.5	19.20
19	Do. (picked) ...	57.30	41.2	1.50
20	Bankijora ...	43.50	42.0	14.50
21	Teesaphoolie ...	48.80	37.20	14.0
22	Ghutkum ...	43.20	44.40	12.40
23	Lohundia ...	45.20	44.80	10.0
24	Bhora ...	25.20	37.20	37.60
25	Dangaparah ...	35.40	45.40	19.20
26	Ghatthoura ...	41.60	28.80	29.60
27	Ranigunj Field.			
28	Ranigunj ...	50.8	36.0	13.2
29	Do. ...	50.3	36.3	13.4
30	Searsole ...	51.1	38.5	10.4
31	Do. ...	57.25	41.0	1.75
32	Nimcha ...	47.0	31.50	21.50
33	Banara ...	47.0	40.0	13.0
34	Mungulpur ...	43.9	38.4	17.7
35	Do. ...	44.75	37.0	18.25
36	Babusole ...	46.0	35.4	18.6
37	Madabpur (Haripur) ...	51.1	35.4	13.5
38	Parasia ...	44.0	32.0	24.0
39	Toposi ...	49.20	35.40	15.40
40	Do. ...	58.75	31.50	14.75
41	Chokidanga ...	56.50	35.0	8.50
42	Do. ...	56.80	34.0	9.20
43	Dhoenul ...	55.26	34.0	10.74
44	Jot Janki ...	48.50	30.50	21.0
45	Gopinathpur ...	53.25	35.25	11.50
46	Bonabab ...	48.4	38.7	12.9
47	Kasta ...	61.40	28.0	10.60
48	Do. ...	43.50	32.80	23.70
49	Jemeri ...	55.60	34.0	10.40
50	Futtypur ...	63.80	25.0	11.20
51	Mainanagpur ...	54.85	36.52	10.13
52	Rogonath-Chuck ...	50.50	36.0	13.50
53	Do. ...	46.90	35.0	18.10
54	Banali ...	42.60	44.20	13.20
55	Bhangaband ...	40.30	28.40	31.30
56	Chinakuri ...	53.20	35.50	11.30
57	Hatinal ...	61.0	27.50	11.50
58	Mahuldabar ...	39.20	25.60	35.20
59	Therria Coal-field.			
60	Lodona ...	63.0	26.0	11.0
61	Do. ...	53.8	18.0	28.2
62	Do. ...	66.0	21.5	12.5
63	Do. ...	68.4	20.5	11.1
64	Do. ...	65.8	14.0	20.2
65	Assam.			
66	(?) ...	56.94	41.1	1.86
67	Namber River ...	80.80	40.40	28.80
68	(?) ...	39.8	35.2	25.0
69	Terap ...	61.8	36.5	1.7
70	Namechick ...	50.4	44.6	5.0
71	Jeypur ...	58.0	43.8	3.7
72	Raipoor ...	66.0	31.2	2.8
73	Central India.			
74	Pench River.			
75	Senda ...	61.0	16.0	23.0
76	Burkoi ...	30.3	26.0	23.7
77	Bootaria ...	49.3	26.5	24.2
78	Singori ...	61.6	28.0	10.4
79	Sonadi ...	54.4	29.6	16.0
80	Burkoi ...	57.27	24.0	18.73
81	Mopani (Nerbudda) ...	48.54	33.37	18.09
82	Nepal ...	50.8	47.0	2.2
83	Do. ...	34.08	54.02	11.9
84	Salt Range ...	46.9	48.0	5.1
85	Chittagong ...	37.15	46.50	16.85
86	Sandoway ...	37.3	14.0	48.7
87	Madras.			
88	Godavery river ...	23.3	20.5	56.2
89	Do. ...	28.0	17.6	59.4
90	English Coal saleable at Calcutta.			
91	1 ...	70.3	27.5	2.2
92	2 ...	63.8	34.2	2.0
93	3 ...	74.6	22.6	2.8
94	4 ...	65.8	30.8	3.4
95	5 ...	66.0	31.0	3.0

Rejecting from this number, for present purposes, all those which are from localities where no *workable* amount of coal can be looked for, and taking in this way the first seventy-four on the list, it will be found that the *average* composition, as determined from this number of Indian coals, would be, fixed carbon, 52.2; volatile matter, 31.9; ash, 15.5: whilst the average composition of the fine specimens of English coal given in the table was, fixed carbon, 68.10; volatile matter, 29.20; ash, 2.70. Now the relative duty or effective power of coals may be taken to vary directly as the amount of fixed carbon which they contain; and, taking this test, it will be perceived that, out of the whole series of Indian coals, only one or two come up to this average, or, in other words, that the very best coal of Indian fields only touches the average of English coals. If, on the other hand, we take the relative amount of ash, matter which does not contribute to the heating power of the coals, it will be found that the average of Indian coals shows no less than 15½ per cent., as against less than 2½ per cent. in English coals. These figures show how very seriously inferior to ordinary English are the Indian coals. The two most heavily worked lines of railway in India, namely, the East Indian (Bengal) and the Great Indian Peninsula (Bombay), use, respectively, Indian and English coal; and their relative consumption is 150 tons per mile in the former, as compared with 75 tons in the latter. It is therefore certain that Indian coals are not capable of more than two-thirds, and in most cases not more than one-half, the duty of English coals; and this becomes a most important element in attempting to form any estimate of available quantity.

The relative amount of ash, which, as useless matter, will also most materially affect the cost of carriage, if that amount be, on the average, 15.5 per cent., it is obvious that in every ton of coal carried about one-sixth of useless matter is also carried; and this becomes a very important element when space or stowage is concerned. This inferiority of the Indian coals has prevented their being much used, therefore, in any cases where the fuel is not to a large extent locally attainable. Very few sea-going steamers, for example, will burn "country coal." The agents for the British India Steam Navigation Company state that their experience of Indian coal has been very limited, so far as sea-going steamers are concerned, as they had not found it suit their requirements well for the following reasons: "1st. Speaking generally, and without having gone into experiments to ascertain exactly the properties of Indian coal, we find that to produce a given heat, about one-half more is required of Indian than of good English coal. 2nd. We do not find it to have so injurious an effect on the heating surface as English coal, as it forms a slag, and protects the iron from the effects of the heat; and, again, it is open to an objection in this respect, as the slag blocks up the furnace bars, and prevents ventilation. 3rd. The ash and clinker turned out being, roughly speaking, about 50 per cent. greater than results from the use of English coal, the staff of firemen and coal-trimmers is increased in a corresponding ratio. 4th. Rubble coal being alone used for steamers, it occupies much more space in the bunkers; small coal will scarcely burn, being so earthy and impure." They also add, "We do not find English and country coal to burn well together, although, for economical reasons, we occasionally mix them. The country coal requires the furnaces to be so frequently cleaned that the unconsumed English fuel is drawn out before it is fully exhausted."

SUEZ CANAL.

FROM the beginning of the works on the Suez Canal till the 30th June last, the sum spent by the company amounts to 9,489,859*l.*, of which 1,777,564*l.* went on interest on shares, 499,565*l.* in expenses of administration, 3,925,886*l.* in the construction of the canal and ports, 1,251,059*l.* in materials, and 1,175,116*l.* in advances to contractors. From payment of calls, the Viceroy of Egypt's indemnity, the sale of the domain of Ouady, and other sources, the company have received 12,367,986*l.* The total cost of the canal will be 15,400,000*l.*, of which 7,993,160*l.* is for the canal itself, 2,960,000*l.* for interest on shares, and the rest for sundry matters. In the first six months of the present year the traffic on the canal from Ismailia to Suez produced 20,855*l.* It has been announced that several great steam-navigation companies have already begun to utilise Port Said, or are in negotiation to do so. A call has recently been made on the shareholders for 4,000,000*l.* of additional capital, on the assurance of M. de Lesseps that the canal will really be finished in October, 1869.

GRIFFIN'S PERMANENT WAY.

THE system of cast-iron chair sleepers designed, or invented, by Mr. G. F. Griffin, of Great George-street, Westminster, some six or seven years ago, appears, after a few years' trial on some of the lines in this country and abroad, to be coming into great favour with railway engineers. We have already stated that large quantities of such sleepers are now being produced at the Phoenix Foundry, Glasgow, these sleepers being destined for two or three different railway lines in Europe and America. The essential features of Mr. Griffin's invention were very clearly and elaborately pointed out in a paper read before the Royal Scottish Society of Arts at Edinburgh, by Mr. W. J. Cockburn Muir, about six months ago. Mr. Muir states that his attention was first drawn to this system of permanent way when the concessioner of the Central Argentine Railway (Mr. Wheelwright) consulted him with regard to its applicability for that line, which traverses 260 miles of pampa westward from the Orona river. Mr. Muir having advocated its adoption, a trial was made, and the results were so satisfactory in the opinion of the engineer, Mr. Wood, and of Messrs. Brassey and Co., the contractors, that the extension of the Western Railway of Buenos Ayres, about fifty miles in length, has also been laid with these sleepers. Griffin's sleepers have also been adopted for the Uruguay Railway, and his system is gaining ground in Brazil, Egypt, India, and Spain. A short length of this permanent way has been laid down on the Great Northern Railway, near London, and it is stated to have carried the heavy traffic of from two hundred to three hundred trains daily for nearly six years with complete success. Similar results have been obtained on the London and South-Western line, near Nine Elms, and on the London, Chatham, and Dover Railway. The essential features of Griffin's sleepers are a rectangular base of considerable extent or area, a continuous bearing of the rail in its chair all over the length of the sleeper, and the entire assimilation of form and outlines between sleeper and chair. We shall, at an early date, publish engravings of the Griffin chair sleeper in its present form, which is a considerable improvement upon the original design. The chair sleeper is in plan a parallelogram of from 23 in. to 30 in. by from 16 in. to 18 in., laid lengthways under the rail. In section its upper portion resembles an ordinary chair, while the lower part has a double or return flange, of which the horizontal member bears flat on the ballast, and the vertical cuts into it. The sleepers are held to gauge by tie-bars having return ends, so that no cotter is needed; the number of tie-bars is one or two for each pair of sleepers, according to the nature of the traffic and of the ballast. The advantages which this form of sleepers offers over cast-iron sleepers of other forms are the great stability which is due to the broad square base gripping the soil or ballast below, by means of its vertical flange, and preventing the loose material from giving way laterally, and the long bearing surface between the rail and the chair leaving only a very short piece of rail unsupported between each pair of sleepers. The section of rails can, therefore, be reduced for the same weights of engines without lessening the stability of the permanent way, or increasing the tractive force required for working the trains. Compared with wooden cross sleepers, the Griffin system has the advantage of being more permanent, requiring less attention and labour in packing of the ballast, and of superior economy in first outlay. Mr. Muir has shown by some tables comparing the cost of a wood cross-sleeper road with an equivalent chair-sleeper road, that with present prices there is a difference in favour of Griffin's system ranging from 276*l.* to 296*l.* per mile in first cost, and that a still greater proportionate advantage is to be derived when economy of maintenance and repairs is taken into consideration. Without at present either confirming or contradicting Mr. Muir's statement of costs, we consider it quite obvious that, with the rising prices of timber and the increasing scarcity of wood in most civilised countries, the question of economy must day by day become more markedly in favour of the iron sleeper, and the substitution of iron for wood in all portions of the permanent way of railways appears to be at present a question of time only.

ACCIDENT AT THE HOOSAC TUNNEL.—A sad disaster occurred on the 19th of October at the Hoosac tunnel in Massachusetts. To facilitate the boring, a shaft has been sunk from the top of a mountain, and a gasoline factory is situated on the surface, near the mouth of the shaft. There was an explosion in the factory that blew it to pieces, and threw the burning fragments down the shaft. Thirteen men were working in the shaft at the time, and all of them were killed.

INSTITUTION OF MECHANICAL ENGINEERS.

The general meeting of the members of this Institution was held on Thursday, the 31st October, in the lecture-theatre of the Midland Institute, Birmingham; Sampson Lloyd, Esq., vice-president, in the chair.

The secretary (Mr. W. P. Marshall) having read the minutes of the previous meeting, a number of new members were elected, and the officers of the Institution were nominated by the meeting for the next annual election.

The first paper read was a "Description of the Pumping Engines at Crossness, for the Metropolitan Main Drainage Works," by Mr. Gilbert Hamilton, of Messrs. James Watt and Co. These engines are situated at Crossness Point, about four miles below Woolwich, where the southern outfall sewer for the drainage of the southern portion of London discharges into the Thames; and the sewer being below the low-water level of the river, the engines are employed for lifting the sewage into a large covered reservoir at a higher level, whence it is allowed to flow direct into the river during the ebb tide, the average height of lift being about 26 ft. There are four independent pumping-engines, each working two sets of pumps, and each of these sets consists of four single-acting plungers, all working in one cylindrical casing. The suction and delivery valves are leather flap valves loaded with wrought-iron plates, the former being placed in a horizontal position, and the latter nearly vertical. The plungers are worked by connecting-rods from the engine-beam, and the motion is controlled by a heavy fly-wheel coupled to the end of the beam; the engines are double-acting, high-pressure, and expansive, and the work done in the up and down strokes is equalised by placing one set of pumps on each side of the beam centre. The pumps discharge into a central wrought-iron trough, closed at the top, and provided with an air-vessel to ease the action of the pumps when working against a head pressure in the reservoir. These engines have now been at work more than two years, and in ordinary fair weather the usual amount of working is one engine constantly pumping, and two others for a portion of the time; but this varies greatly and suddenly with the weather, and sometimes the four engines are at full work together for some hours after a heavy rain in London, the effect of which is generally felt at the engines about six hours afterwards. The four engines together discharge seven million gallons per hour, and are capable of filling the reservoir in 3½ hours, the total content being twenty-four million gallons. Indicator diagrams were exhibited from the engines, the duty of which is found to be eighty-six million pounds raised one foot with a consumption of 1 cwt. of Welsh coal.

The next paper was a "Description of an improved Steam Pile-driver with Endless Chain," by Mr. Peter B. Eassie, of Gloucester. In this pile-driver the endless chain is made to lift the ram by its centre of gravity, in order to obviate the loss of power arising from the friction produced by the binding of the ram upon the leaders in lifting, when the attachment of the chain is at a point behind the ram, thereby canting the ram against the leaders, as in the ordinary pile-drivers. In the improved pile-driver, designed by the writer, the endless lifting chain, ascending at the back of the leaders, is brought forward in front of them, and into the line of the centre of gravity of the ram, by means of a light slide or "follower," sliding freely up and down between the leaders, and carrying a roller, under which the chain passes from the back to the front of the leaders. During the ascent of the ram, the follower simply rests on the top of it, and is carried up by it; and as soon as the ram is liberated and falls, the follower runs down after it upon the ascending endless chain. This sufficiently retards the descent of the follower to allow time for the rebound of the ram after striking the blow to cease, before the follower overtakes it and brings the lifting chain forwards to engage with the hook on the ram, thus preventing any risk of the ram being caught by the lifting chain in the rebound. The lifting hook is constantly pressed inwards by a spring, ready to engage in the links of the endless chain; and the attachment of the hook to the ram is made with a spring, in order to ease the strain caused by the weight of the ram being thrown suddenly on the lifting chain, by the hook engaging in the chain while moving at a considerable velocity. The ram is dropped by the lifting hook being disengaged from the chain by means of a "striker-off," which slides freely between the leaders, and carries a pair of bell-crank levers, with a roller in front of the leaders; the lifting hook coming in contact with this roller is thrown out of the chain, whilst giving the levers a nipping action against the leaders, which prevents the striker-off from rising. The height of fall is regulated by raising or lowering the striker-off, which is suspended by a cord in the required position. The endless lifting-chain being kept running always in the same direction, the engine never requires to be stopped or reversed during the performance of the work, nor are any reversing clutches required for reversing the motion of the crab. For driving piles below the level of the machine itself, a telescopic arrangement is employed, consisting of a long frame called a "needle," sliding freely between the leaders of the pile-driver, and lowered by chains to the required depth below the machine; this frame then serves as the guide for the ram and follower, in place of the leaders themselves, and the endless lifting chain is conducted from the crab round a pulley at each extremity of the "needle." By this means piles are driven in trenches by a pile-driver travelling on rails carried upon ganties erected above the top of the trench, whereby the pile-driver commands every portion of the space included between the ganties. The pile shoes at the bottoms of the piles are formed of hollow castings, affording a broad base to the wood of the pile itself, and having dovetailed recesses cast on for the attachment of the wrought-iron straps, which are then fastened to the pile by spikes in the ordinary manner; this construction has the advantage of economy of space in stowage, owing to the shoe itself being a separate piece from the straps. Specimens of the shoes were exhibited, and a working model of the pile-driver was shown in action.

The third paper was a "Description of the Steam Steering

Gear in the Great Eastern Steamship," by Mr. J. McFarlane Gray, of Messrs. Forrester and Co., Liverpool. Until the present year the Great Eastern was steered by manual power alone, but the want of a steam steering gear was greatly felt from the first, and the same want is seriously felt also in all large steam-ships; and the automatic steam steering gear, designed for the purpose by the writer, was constructed for the Great Eastern by Messrs. Forrester and Co., of Liverpool, under the inspection of Captain Sir James Anderson. The apparatus consists of a steam-engine placed at the stern, having a pair of horizontal cylinders, working cranks at right angles, and geared to the original rudder-shaft, which works the chains moving the tiller without any alteration of the original arrangement for steering by hand. The engine is controlled by a small steering-wheel at the bridge, at a distance of more than 400 ft., which is connected by a shaft, and so arranged that the hand steering-wheels at the stern revolve turn for turn with it, and the steersman at the bridge steers the ship by the small wheel through the power of the engine. The reversing, stopping, and starting are effected by the automatic stop-valve of the engine, which is a hollow cylindrical slide, covering both the steam and the exhaust passages, so that according to its position it can reverse the action of these passages, thus making the engine go in either direction by changing the exhaust into steam passages, and the steam into exhaust. The movement of this automatic stop-valve is effected entirely by the longitudinal travel of a differential screw, which constitutes the self-regulating portion of the steering gear; the screw is geared to the long shaft from the bridge, so as to make turn for turn with the bridge steering-wheel; while the nut in which the screw works is incapable of longitudinal movement, and is geared with the rudder-shaft, so as to make turn for turn with the latter. If the nut be held stationary while the screw is turned, the result is a longitudinal travel of the screw in the nut, and this longitudinal travel is communicated through a lever to the steam stop-valve; but if the nut be made to revolve in the same direction as the screw, and at the same speed, no end motion of the screw will take place, and the steam stop-valve will be kept stationary. Hence the actual longitudinal travel of the screw corresponds always to the difference between the motion of the steering-wheel and of the rudder-shaft, the screw being thus a differential apparatus. When the engine and the steering-wheel are at rest, the steam stop-valve stands in its middle position, closing the cylinder ports entirely, both to the steam and to the exhaust; but if the steering-wheel be turned, the differential screw being thereby also turned, travels endways in its nut, and opens the stop-valve sufficiently to make the engine revolve in the direction corresponding to the revolution of the screw. The rudder-shaft being driven by the engine, will thus also revolve, and with it the differential nut; and the screw continuing to travel endways until the nut and screw both revolve at exactly the same rate, the stop-valve will continue to open until the motion of the engine corresponds exactly with that of the steering-wheel. This self-acting adjustment of the stop-valve is all done at the very moment that the steering-wheel is moved, in consequence of the automatic action of the differential screw, so that the motion of the rudder-wheel at the stern is sensibly simultaneous with that of the steering-wheel at the bridge. If there is a strain on the rudder in the position in which it is required to be held, the steam stop-valve does not shut altogether, and the engine becomes simply an automatic steam-brake, requiring no attention from the steersman; the holding power of the engine however is limited by the steam pressure, and is an elastic force that yields to any sudden excessive strain from a heavy sea striking the rudder, but immediately afterwards restores the rudder to its proper position. If the strain alternates from one side of the rudder to the other, the stop-valve immediately reverses its position, so as to bring the steam pressure on the opposite side of the pistons. However suddenly or violently this alternation of strain may take place, the differential screw is constantly ready for work, and its action is far more perfect and trustworthy than the labour of any number of men at the wheels; the differential screw is in fact a perfect automaton, changing the action of the steam stop-valve, not after the change of strain on the rudder, but by that change itself, and simultaneously with it. As it was desired in the case of the *Great Eastern* to have the means of disconnecting the steam gearing gear at any time and substituting manual labour at the stern rudder-wheels, an indicating dial was arranged in connexion with the differential steering gear, having two pointers, one of which, being connected with the rudder-shaft, showed the position of the rudder, while the other, being worked from the bridge steering-wheel, directed the movements of the men at the stern wheels, whose duty it was to maintain the rudder-index coincident with the directing index, any deviation of the rudder from the required position being magnified upon the dial by the directing index. A self-acting signal bell was also added, for calling the attention of the men whenever any divergence occurred between the two pointers, requiring the rudder-wheels to be put over in either direction; and the bell sounded again, as soon as the two pointers became again coincident. The steering-wheel at the bridge, controlling the motion of the steam steering gear, is provided with stops corresponding to the two extreme positions of the rudder; and also with a safety-clutch, which gives way under any force turning the steering-wheel beyond either of the extreme positions. In working the steering-wheel, no power is required at any time except to overcome the friction of the shafting and gearing for moving the engine stop-valve, which is in equilibrium; and the steering-wheel can consequently be turned with one finger, while at the same time moving the rudder of the great ship more promptly than was practicable with the greatest force of men that could be brought to work at the ordinary hand steering-wheels. The last voyage of the *Great Eastern* from Liverpool to New York was a very stormy one, and afforded an excellent opportunity for trying the efficiency of the steam steering gear, which steered the ship with entire satisfaction during the passage from her moorings in the Mersey. When approaching Cape Race, at the end of the voyage, the sea being very rough, the men were ordered to take the wheels, and the steam-gear was disconnected, not because there was any defect in it, but be-

cause a storm was coming on and the vessel was on a dangerous coast, and there had not then been any experience of the steam-steering in a storm. It soon became evident, however, that the vessel was not steered so well by manual labour as before, and the men were becoming quite exhausted; when the steam steering gear was again connected; and this was used all through the storm, which was so severe as to necessitate turning the ship about for some time. This operation in such a sea would have been almost impossible with so large a ship as the *Great Eastern* in steering by hand; but it made no difference to the steam-steering engine, and even when the ship got into the trough of the sea, the steering-wheel at the bridge was quite passive in the hand of the steersman, and could be moved as easily as in a calm. The result was so satisfactory that Captain Anderson reported that the steam steering gear seemed perfect.

The meeting then terminated.

PLUMBAGO STEEL.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter of "S.," in your last issue, so fully bears out some experiments of mine that I take the liberty of mentioning them:

Some years ago I was interested in a patent for manufacturing steel in the crucible direct from the iron, without cementation, and took some small works at Sheffield for the purpose of experimenting—employing Sheffield workmen. These naturally wished to use the clay crucibles, and it was some time before I could get them to use plumbago crucibles. After a time, however, I did so, and succeeded in manufacturing steel which was equal to any made in Sheffield, and much more uniform than that made in the clay crucible. In addition to that, we managed to get four heats a day instead of three, and used less fuel.

I am, Sir, yours, &c.,
F. P. S.

November 4, 1867.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter of your correspondent, "S.," on the above subject, suggests a few observations which may perhaps be of some practical value in the event of further experiments being carried out.

The greatest drawback to the manufacture of plumbago steel has hitherto been the difficulty of obtaining the plumbago in a state of purity, and probably the presence of a considerable quantity of lime in most samples would contribute not a little to the failure of experiments in this direction.

The process now adopted at these works for the purification of plumbago entirely removes this difficulty, as it completely separates the lime, oxide of iron, alumina, and other saline and earthy matters, leaving the pure carbon.

I apprehend that the question as to the relative cost of charcoal and plumbago may be settled by a very few experiments, inasmuch as the charcoal will be found to have materially diminished after each heating, whilst the purified plumbago remains nearly unaltered by the heat, and will thus prove ultimately by far the cheaper material of the two.

I am, Sir, yours, &c.,
R. G. BLUNT,
Chemist.

Battersea Works, S.W., Nov. 4, 1867.

PROPOSED ABANDONMENT OF A RAILWAY.—The North-Eastern Railway Company have given notice of a general meeting of the shareholders on the 19th inst., "for the purpose of determining whether application shall be made to the Board of Trade that the railway which the company were by the North-Eastern Railway Company (Leeds and Wetherby Branch) Act, 1866, authorised to make may be abandoned. The Leeds and Wetherby was the fighting line by which the North-Eastern Company defeated the Leeds, North Yorkshire, and Durham project, and its true character is now apparent by the desire to abandon it. The North-Eastern meeting will also be made special to sanction issue of 4½ per cent. debenture stock in lieu of debenture bonds.

THE CLEVELAND IRON TRADE.—The number of furnaces in blast in the Cleveland district is eighty-five, and there are forty-nine out of blast. The stocks of pig-iron in the makers' hands are considered to be decreasing, and the quantity in the warrant stores is now estimated to be below 72,000 tons. The cargoes cleared out have been principally for autumn deliveries to Norway and the North German ports; a few shipments have also been made to France. Orders for bowl sleepers for Egypt and chairs for India are being rapidly worked out. A good many vessels have recently cleared out for Alexandria. A plackness is complained of as regards pipe orders. The deliveries of rails for Russia are about completed. Some orders for rails are on hand for Dutch and Dutch-Indian railways.

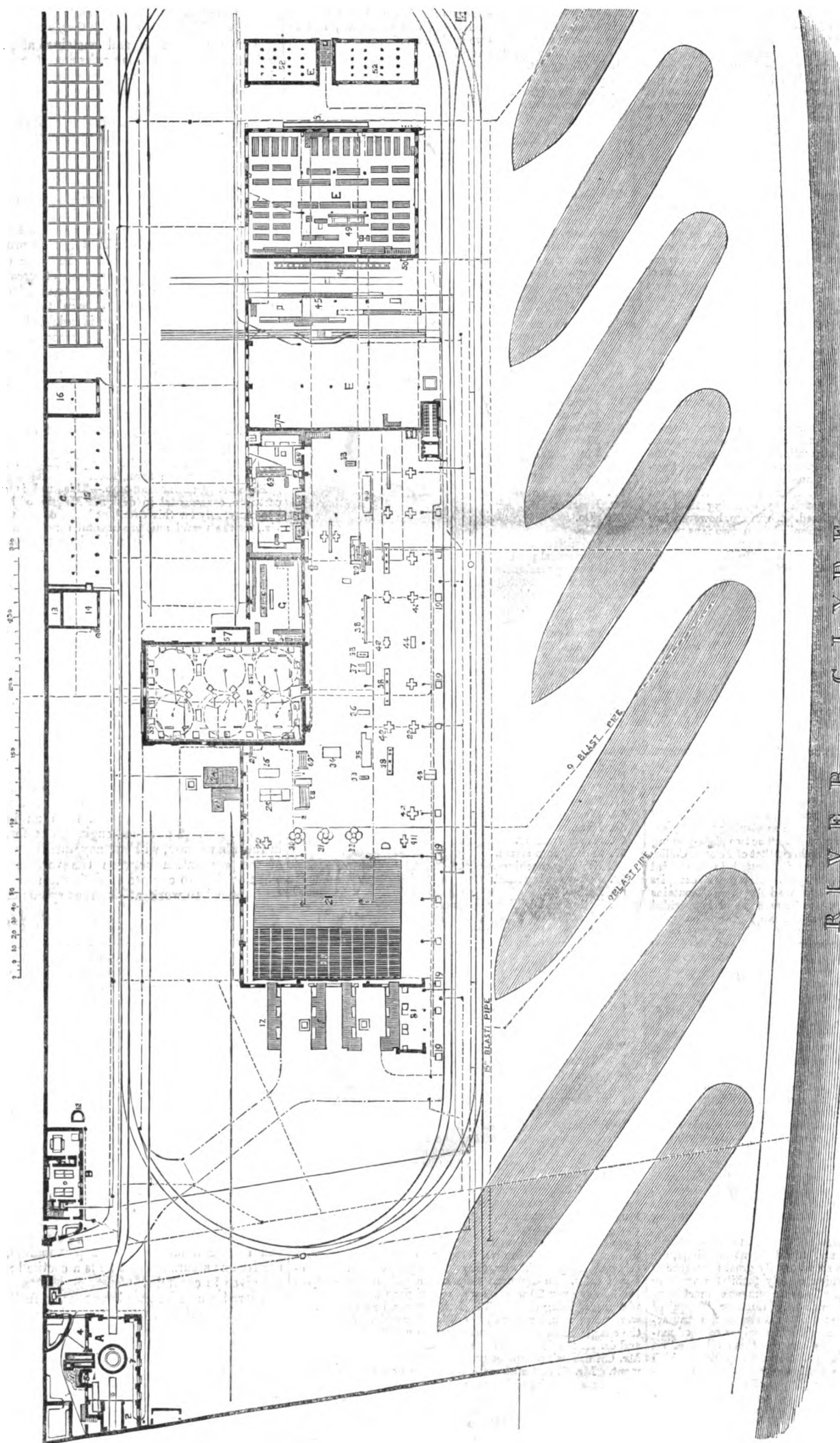
THE CITY OF BUENOS AYRES (S.S.).—This steamer, built for Messrs. Tate and Co., of London and Limerick, by Messrs. Richardson, Duck, and Co., of Stockton, and intended to be employed in the Brazilian trade, attained on her trial trip a speed of 11 knots per hour. The City of Buenos Ayres is 878 tons burthen, and Messrs. F. Richardson and Sons, of Hartlepool, have fitted her with engines of 200 horse power nominal.

INDIAN TELEGRAPHY.—In reply to a communication from the Manchester Chamber of Commerce with regard to telegraphic communication with India, via Gibraltar, Malta, and the Red Sea, the Indian Government has intimated that it will not guarantee interest on the capital required to be expended, but that, in other respects, it will accord all possible facilities for the development and prosecution of the undertaking.

Messrs. HOPKINS, GILKES and Co.—This company has brought into operation two new blast furnaces, which have been in course of erection for more than a year past, adjoining the Leeds and Linthorpe Ironworks at Middlesbrough. The furnaces are 75 ft. in height, and their weekly production is estimated at 700 tons. The cubic capacity of each furnace is upwards of 20,000 ft.

THE FAIRFIELD SHIPBUILDING YARD, GLASGOW.

MESSRS. RANDOLPH, ELDER AND CO., ENGINEERS AND SHIPBUILDERS.



THE shipbuilding laid out at Fairfield, at a comparatively recent date, by Messrs. Randolph, Elder and Co. may be justly considered a model establishment of its kind. Messrs. Randolph, Elder and Co. have had abundant space at their disposal, as the yard, as far as it is yet completed, does not cover more than half the available site belonging to the firm, and they have, moreover, had the advantage in planning the arrangements of accumulated experience gained during their previous extensive practice. The Fairfield yard is the largest

shipbuilding yard on the Clyde, and when the original plans were prepared, the whole of the site was completely laid out, so that any extensions of the present yard can, from time to time, be made as occasion may require, without interfering with the general design. On the present page we give a complete plan of the Fairfield Shipbuilding Yard and of its workshops as they now exist, this plan being copied from an accurate scale drawing kindly furnished to us by Messrs. Randolph, Elder and Co.

The whole area now occupied by the Fairfield yard is about 1200 ft. in length and 500 ft. in width, the river frontage forming one of the longitudinal boundaries, while the opposite and parallel side forms the road frontage and the main entrance to the works. The clear space left for the erection of the ships between the lines of rails which pass in front of the workshops and the river-side is about 220 ft., measured at right angles to the river frontage; but the ships being laid down in diagonal lines, so as to give greater

lengths upon the same width of area, vessels of the largest sizes now usually constructed can be laid down on this space. The drawing shows the position of one vessel exceeding 400 ft. in length between its perpendiculars, and it at the same time illustrates that with this size the limit of accommodation is far from being reached. This portion of the yard is, of course, entirely free from fixtures of any kind, excepting only two 9 in. blast pipes, carried below ground from the fan in the forge, and destined for the supply of blast to the small

portable fires used for heating the rivets, and placed in close proximity to the work performed. The main drain, consisting of a cast-iron pipe 227 ft. long and 18 in. diameter, passes across this portion of the yard at a depth of 8 ft. below the shop-floor, falling to a depth of 15 ft. at its entrance into the river. The space above ground is free for the erection of the temporary scaffolding required for each particular ship, and which must accommodate itself to the shape and dimensions of each particular vessel. At the extreme end of this space a large wharf-crane is placed, and its range connects the river-side with a railway passing all round the workshops, and all over the area of the yard. The whole of the workshops are provided with gas and water by a network of pipes, shown on the plan, the former branching out from a gas-meter close to the main entrance and offices, the latter connected with a reservoir in the yard. On a line of rails passing behind the workshops, and over the entire length of the yard, works a self-acting steam travelling-crane carrying its own boiler and engine upon the frame. Of this crane we expect to give drawings at a future date, and defer the description till then. A complete brass foundry and store occupies the corner of the yard close to the drawing-office and the main entrance. The workshops form three parallel rows of sheds, supported upon cast-iron columns, and they are about 600 in total length. At the extreme end and outside of these sheds are placed the furnaces for heating bars and angle irons, which require bending to shape to form the ribs and other principal elements of an iron ship. For this operation of bending two large plane surfaces are provided, forming enormous drawing-boards, upon which the various forms of these ribs are drawn out in full size; and templates are made, or the articles themselves laid down and shaped correctly, in accordance with these lines. The plane surface, upon which the hot angle-irons are manipulated, consists of iron plates, while the adjoining space used for building and rivetting up angles and ribs when cold is floored with wooden planks, properly planed to produce a smooth and plane surface. The smith's hearths are placed in groups of four, clustered together, so as to stand upon the same base or foundation block. They are accessible from all sides, and the blast is provided from one of the numerous branch pipes leading from the room where the forge-fan is placed. There are, however, two sets of blast pipes in the yard, supplied from two fans placed at a considerable distance apart, the fan next to the forge supplying the former and all the fires in its immediate proximity, while the other fan, placed close to the shed containing the wood-working machinery, supplies two parallel rows of blast pipes, led the entire length of the yard, for the supply of the smaller fires used for heating rivets and similar work.

The punching and shearing machines, which are all made on the usual plan, with gearing and eccentric slides, are placed in two parallel rows behind each other. There are in all thirteen of these machines fixed in the workshops; but there are some smaller additional machines used in the yard. A special machine for shearing angle iron is placed in the front row, between the punching-machines; and the second row is intermixed with drilling-machines, containing each a number of independent vertical drills fixed to a long narrow frame, and worked by a common driving-shaft. These drills are very useful for drilling plates, angles, or bars, several drills being attended to by one man. The engine which works the shop-shafting is placed behind these rows of tools, and as nearly as possible in a central position. The row of machinery which stands in the same line with it, and which, as seen from the river-side, forms the third row of machines, is employed principally in preparatory work, such as planing the edges of plates, bending plates and angles, &c. The two plate-planing machines are on a principle resembling that of Messrs. Collier and Co.'s plate-planing machine illustrated in the third volume of *ENGINEERING*, page 59. The forge occupies a special building behind these workshops. It contains thirty-three fires and four steam-hammers, and is provided with six swing-cranes reaching all over the ground occupied by this shop. A mechanical workshop, for making small details and for executing repairs, is placed close to the forge; but the engineering works proper belonging to Messrs. Randolph, Elder, and Co. are at another place in the central part of Glasgow, and they do not form part of the shipbuilding yard, although it is probable that at some future time the engineering works will be removed, and placed upon some of the spare land adjoining the Fairfield yard.

The extensive workshops which occupy the rest of the main buildings are devoted to carpenters' and joiners' work, which enters very largely into the fitting out of iron ships and into the erection of the temporary structures required for shipbuilding. Some large timber-frames and circular saw-frames are employed for cutting up the timber, which is brought up to these machines from the yard or stores by means of the large traveller. The material enters these shops from the side which faces the offices, and passes out, when completely finished, at the opposite side facing the river. Most of the wood-working machinery is made by Messrs. T. Robinson and Sons, of Rochdale, and both carpenters' and joiners' shops are fitted out with a very complete plant of wood-working machinery. A considerable area of ground is roofed over, besides that occupied by the above-named workshops, and it is occupied by stores for drying wood, by necessary workshops, such as painters', gasfitters', and other shops, and a special shed devoted to boat-building. The machinery and plant, and the different buildings, are spread over the ground with an unusually great allowance of clear space between them, which greatly facilitates working and internal communication. The arrangement of machinery is such that the least possible amount of transport is required for passing the work through its different stages of manufacture to its ultimate destination, and the straight rows of machines with their clear passages between them allow of an easy supervision within the shops. The railway lines, which traverse every portion of the yard where heavy masses require to be moved, make the transport of these latter convenient. A small portable engine and crane, mounted on a truck, and moving upon the rails by steam power, effects the service of locomotion upon these rails with great rapidity and economy, and it communicates upon these railway lines with all the fixed or stationary cranes in the yard, and with the

other travelling-cranes outside and in the buildings. As the scale to which the plan on page 448 is drawn is too small to allow of the names of the various shops, &c., being marked on it, the details have been lettered and numbered, and to these letters and numbers we subjoin a reference.

The brass foundry, A, comprises:

1. Moulding-pit.
2. Core-room.
3. Moulding-boxes.
4. Air-furnaces.
5. Crucible furnaces.
6. Metal-store.
7. Dressing-benches.
8. Stove.
9. Office.

The block of building, B, contains the general offices,

11. Weighing-machine.
12. Iron-measurer.

The block of building, C, comprises:

13. Gas-fitters' shop.
14. Stores for oakum and pitch.
15. Boat-builders' shed.
16. Painters' store.

In the fitting-shop, D, the carpenters' shed, E, the foundry, F, the mechanics' shop, G, the general stores, H, and in the yard near them, are situated:

17. Angle furnaces.
18. Smithy.
19. Fires.
20. Drawing loft with plate-iron floor.
21. Drawing-loft.
22. Punches.
23. Plate-furnace.
24. Boilers.
25. Plates.
26. Plate-bending machine.
27. Fans.
28. Bending rolls.
29. Do. do.
30. Hearths.
31. Do.
32. Do.
33. Grindstones.
34. Horizontal punch and angle-iron scraper.
35. Planing-machine.
36. Punch.
37. Planing-machine.
38. Vertical drills.
39. Engine.
40. Planing-machine.
41. Shears.
42. Punch and shears.
43. Rivet-heater and rivetting-machine.
44. Angle-iron shears.
45. Saws.
46. Planing-machine.
47. Moulding-machine.
48. Morticing-machine.
49. Lathes.
50. Fans.
51. Steam stove.
52. Drying stores for wood.
53. Furnace.
54. Wood-measurer.
55. Fires.
56. Steam hammer.
57. Smiths' iron stores.
58. Nibbling-machines.
59. Bolt-screwing machines.
60. Lathes.
61. Lathes and drilling-machines.
62. Vices.
63. Rivet stores.
64. Riveters' counter.
65. Carpenters' do.
66. Joiners' do.
67. Oil stores.
68. Nail do.
69. Weighing-machine.
70. Storekeeper's office.
71. Dowelling-machine.

THE TELEGRAPH AND THE POST-OFFICE.—The Edinburgh Chamber of Commerce has resolved again to memorialise her Majesty's Government to introduce a bill to provide for working the telegraphic communication of the country through the medium of the post-office. The chairman (Mr. Harrison), in making the motion, said, that for the interest of the telegraph companies, as well as the interest of the public, it was very desirable that Government should decide one way or other what they were to do in this matter. In some observations on Mr. Grimstone's pamphlet, he said the experience of Belgium was the best answer to the statement that the country postmasters and postmistresses could not be taught to work the telegraph. The public would not, he thought, be worse off than at present, when in the public news the mistakes were often ridiculous, and the errors in private telegrams often very costly to the senders and receivers. They might also, through the post-office, expect reduced rates. In Belgium they had a uniform rate of 5d. (half-franc) per 20 words, and the Belgians were now complaining of being charged 10d. for 21 words, believing 1d. per word extra would repay the additional trouble. At present the charge from Edinburgh to London was 2s. for 20 words, and 4s. for 21. Mr. Harrison concluded by observing that Mr. Grimstone's pamphlet gave them no promise of improvement. Mr. R. S. Smith expressed some doubt as to the desirableness of extinguishing the competition of different companies. When he found blunders committed by one company he was in the habit of punishing them by going to another. But he did not object to the chamber urging upon Government to deal with the matter. The motion was unanimously agreed to.

AN ENGINEERING "NICHOLAS."

'Tis pleasant, sure, to see one's name in print;

A book's a book, although there's nothing in't.

AFTER responsible and sustained attention to the weightier matters of his profession, the engineer may find recreation in the vagaries of budding genius, even where its sprouts appear at the somewhat mature age of forty. A well-known comic paper has made famous one of its characters, a dissipated, impecunious, and offensively patronising race-prophet, "Nicholas;" and a certain engineering journal may, perhaps, take credit to itself for having introduced to the public several years ago the original of this popular but imaginary vaticinator, so far, at least, as his style of expressing himself is concerned. Mr. Nicholas Procter Burgh does not, it is true, apply the energies of his mighty mind to prophecy, but in his various literary productions he has unquestionably pretypified the style of the other Nicholas, "than whom a prophet of greater potatory power, although a little given to murdering the dictionary"—to employ his own favourite form of aposiopesis. The profession is indebted to Mr. Burgh, to his publishers, and to his recognised organ, *The Engineer*, for many productions of singular originality, all having the true Nicolaitan ring. So diffuse are his contributions to practical science that we can refer to but few here; but we may be allowed to reproduce the following gems, trusting that our readers will not find their flashing brilliancy beyond what the eye and the mind may fairly withstand.

From *Burgh's Practical Rules for Modern Engines and Boilers*. London: Spon, 1864.

Page 28. CONNECTING-ROD.—This rod is generally of cast iron, ornamental in design. Makers of beam-engines, generally, rely on this detail, as ladies do on their bonnets, viz., for the useful and ornamental conclusion of the paraphernalia of the whole, in which both parties delight to indulge.

On pages 8, 31, and 38, we have the following various "rules" for the outside lap of the slide-valve.

Page 8. Outside lap of slide-valve = $\frac{\text{width of supply port}}{2 \text{ to } 3}$

Page 31. Outside lap of valve = width of port supply $\times 0.5$ to 0.6 .

Inside lap = $\frac{\text{outside lap}}{6}$

Page 38. Outside lap = width of supply port $\times 0.6$.

Inside lap = $\frac{\text{outside lap}}{8}$

To show that the latter, and not the former rule, is right, it is repeated a dozen lines further on. We suppose that no engineer need be informed, however, that the lap of a valve is not a function of the width of the "port supply." The whole book is a collection of "rules," apparently prepared from an inspection of sets of drawings of actual engines, but formulated, as in the above case, without any intelligent knowledge of the correlation between the various dimensions when applied to engines of different size and design, or intended to work at different speeds or grades of expansion.

Mr. Burgh subsequently issued an extraordinary treatise upon the slide-valve, also conceived in the true Nicolaitan spirit, and in last week's *Engineer* we find him dealing with the same subject in a style of passing profundity, and with abundant evidence that the author had swallowed a dictionary. We must needs, therefore, look into our own, and if we deal with Nicholas subderisively, we shall not at any rate do so picromeliously. We recognise in his style and matter the true *vivida vis animi*, and even if the former be bad, we shall content ourselves with describing it as awful cacology, and if the matter be empty, as consummate galimatias. The sugescent engineer, in other words, the sucking student of the writings of Nicholas, may indulge in nictitation, but no $\chi\lambda\omega\pi\sigma$, we trust, will be discernible in his albuginea. At most, we wish only to induce an extensive surculcation of Mr. Burgh's writings, after which we trust their circulation, which is quite another matter, may be immense; and if this engineering Nicholas is displeased with us, he may call upon us and receive a modicum of supernaculum, and also receive our assurance that he is a coctile brick, even if not given to cocktails.

There! we believe we have now no further use for our dictionary. Let us get to business.

The Engineer devotes a page and a half to Mr. Burgh, who pretends to describe means whereby the "veracity" of an indicator diagram may be tested, in case suspicion may arise, as on certain steamship trials, that it has been "cooked." Says Mr. Burgh:

Now besides the speed of the hull, the indicated power of the engines demands attention, and when Mr. E. J. Reed and Sir E. Belcher gave their views on the subject of steamship trials, they seemed to have overlooked this fact. It is evident

that a steamer may attain a fair speed, but at the cost of excessive power, and unless there be some check, "jockeying" in that direction may be resorted to, inasmuch as an indicator diagram can be made by other means than by the indicator. That such an occurrence ever took place is not in my experience, neither do I even hint that it ever will, my intention being to explain a means of testing and knowing the veracity of a diagram, and to show that this important matter has been overlooked by those most ready to complain of unfair means used to attain the best result.

Then comes the pretended proof of the "veracity" of the indicator diagram, and this is a bungling explanation, at great length, of what every draughtsman at an engine-works must know, viz., that the diagram is formed according to the points in the stroke at which the valve opens and closes the steam port and exhaust port respectively, and that these points are governed not alone by the proportions of the valve with reference to the ports, by the travel of the valve, and by the angle of the eccentric with respect to the crank, but also to some extent by the obliquity of the connecting-rod and eccentric-rod respectively, at various points in the revolution of the crank. Any competent engine draughtsman, having these particulars before him, can construct a theoretical diagram; but he can neither predetermine the actual initial cylinder pressure, nor the vacuum, nor the extent of wire-drawing, nor the amount of steam which may leak under the valves in case they do not fit closely, nor the loss of pressure due to condensation within the cylinder itself. In other words, he can make a theoretical diagram without Mr. Burgh's assistance; but with it he cannot get any nearer to a knowledge of what the actual diagram will be, before the indicator is once on, and the engine has spoken for itself. Next, as to the virtues of expansion. A case is cited in which the steam is cut off before the end of the stroke, and thus, it is said, "the steam in the boiler is allowed to accumulate for a time—this is one advantage of an early cut-off: time is allowed for evaporation in the boiler, and a saving of steam results by getting the greatest possible power from a given quantity during the stroke of the piston." We were not before aware that any more time is given for evaporation when the engine works expansively than when it takes steam for the whole stroke. As long as there are sixty minutes in an hour, and no more, we fear that, expansion or no expansion, a boiler can do but sixty minutes' work in an hour, and we need hardly add that the quantity of water which a marine boiler can and will evaporate, under a full fire, has nothing to do with the rate at which the steam is taken into the cylinders; for if the steam does not go into the engine, it must either blow off at the safety-valves, or the boiler must burst.

Next we have a supposititious case of an engine cutting off, first, at one-quarter and next at one-half stroke. In the latter case, we are told, double the capacity of cylinder is open to the boiler (which is even more than true, being a matter of course), but also "double, or nearly so, is the time allowed for the steam to escape from the boiler (into the cylinders), and therefore double the amount of steam consumed at each stroke of the piston." Now Nicholas, who, we are sure, writes but to study, has not yet learnt, what every engine draughtsman knows, that supposing uniform circular motion of the crank, and dismissing the consideration of the obliquity of the connecting-rod, as we may do in this case, the second quarter of every stroke of a steam-engine piston is necessarily performed in exactly one-half the time of the first quarter. The impressive "therefore" is thus altogether irrelevant, for if the quantity of steam taken into the cylinder depended wholly or chiefly upon the time the induction port was open, but one half as much would enter on the second as on the first quarter of the stroke. However, it is all one to Nicholas, and he tosses off the subject with a "So much for the supply. Now for expansion!" Now, indeed, and what crystallised knowledge does Nicholas draw from the innermost caverns of his brain! "When," he says, "the steam is in the cylinder, and the valve for a time is closing the port, the steam is expanding, simply because the piston is advancing, and therefore more space is allotted for the steam!" Ah, Nicholas! had you said nothing about "when the steam is in the cylinder," but kept to "when the sherry wine's in, the wit's out," we should have understood you. On reference to your dictionary, you will discover the difference between "closing" and "closed," and it will perhaps occur to you that the steam is not expanding while the port is closing, but, if there be no wire-drawing, only after it has been closed. Neither does the steam expand "simply because the piston is advancing," any more than steam is used in a locomotive engine simply because the train is in motion, nor is the steam waiting in order that "space" may be "allotted" to it. Your dic-

tionary will explain to you the meaning of "because," which is merely "by cause of." It is the business of the steam to make space for itself, and to keep the piston going like a shuttle.

"Lastly," saith Nicholas, "we have compression, so termed, because if there is any steam or air in the cylinder, it cannot escape, neither will the vacuum be impaired—perfection of the valve surface to be accepted—and the piston is driving all before it; besides, the valve is closing the port until the 'lead' occurs, when the 'release' is met by the flow of the steam from the boilers." Good Heavens! what a picture! A perfect *tableau vivant*. So compression does not impair the vacuum! And the energetic piston, which, a moment before, was advancing on its own account, merely to allot space to the steam, as shares might be allotted in a limited liability company, is now—the steam being off the driving face, and a new resistance being opposed on the other side—"driving all before it!" More than this, there is a "besides," and "the valve is closing the port until the 'lead' occurs." Surely Nicholas means "sherry" instead of "port," and may his sherry never be closed, even if it be for ever closing. Thanks to Nicholas, we learn, that after the exhaust port has been closed, and while compression is therefore going on, "the 'release' is met by the flow of steam from the boilers." We had ignorantly supposed that, during compression, there was no "release." However, Nicholas has placed the matter in its right light, unless, which we hardly like to do just yet, we dispute his authority. "Evidently, therefore," says this distinguished author, who has apparently been reading Mr. D. K. Clark's book ("Railway Machinery") for the first time, "if the steam is governed by the valve, and the indicator is open to the cylinder, the action of the valve must determine the various points of cut-off, release, and compression on the diagram." True, it often does, and probably oftener than otherwise. Who ever asserted the contrary?

"But," we read, "the length of the eccentric and connecting rods will settle the exact position of the piston at the various parts of the strokes." In other words, we suppose, when the piston is at one-half of its own stroke, the length of the eccentric and connecting rods may place it somewhere else, and it may thus occupy, as many have often wished to occupy, two places at once.

Following this we have an attempted explanation of an indicator diagram. First, it is explained, after a fashion, how the length of the diagram represents the length of the stroke, but then, changing his mind, Nicholas informs us that "therefore, the length of the indicator's figure and the piston's stroke are the same," which they never are.

Next we have the following elegant aposiopesis:

Here let it be noticed that as the eccentric's angle is due to the present position of the crank, and that there can be no alteration after the angle of the crank is attained from the angle of the eccentric, and the latter's position from the slide-valve.

We quote exactly, *verbatim et literatim*. But we did not know before, as we now know (upon authority) that "the eccentric's angle" was "due to the present position of the crank," nor that "the angle of the crank is attained from the angle of the eccentric," nor were we aware that the position of the eccentric was "attained" from that of the slide-valve.

Nor did we know, until we pondered upon the oracular words of Nicholas, that "the lead of the valve governs the grade of expansion," although, all else being unaltered, it may certainly affect it.

We have gone up and down the weary columns of Nicholas's revelation, and we grasp gladly at the conclusion. And what a conclusion!

As a conclusion it is not out of place to state that a cursory glance at an indicator diagram is often erroneously taken as conclusive evidence on particular points in question. The observer notices the fall or descent of the pencil, and at that point states the "cut-off commenced," but whether in relation to the "piston" or "crank" remains a mystery. He only knows that if the pencil fell in its traverse a decrease of pressure was the cause, but at what stage of the stroke—piston and crank—he could not say.

Yes, the indicator diagram is often taken, and rightly, too, "as conclusive evidence on particular points in question." And the only living observer, pretending to call himself an engineer, who "noticing the fall or descent of the pencil," could not state whether the cut-off commenced at the corresponding position of the piston, as well as of the crank, would be Nicholas—Nicholas Burgh.

While the subject of technical education is engaging the attention of all thoughtful minds, the newspaper which, a few years ago, was the leading journal of our profession places this insufferable twaddle before its readers! It allows Mr. Burgh full scope, and, before

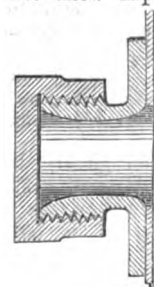
now, has opened its columns to the grossest abuse—even beyond the limits of the law—of those who have pointed out that Mr. Burgh's "designs," published in its own pages, could not, by any human possibility, be carried into practice; in other words, that his proposed engines could not be put together in the hold of a steamship. Need we say more to show that Mr. Burgh is *The Engineer's* own "Nicholas," its chosen expositor of steam-engine practice, and its best interpreter of engineering opinion, so far, at least, as the steam-engine is concerned? Addison has used a word, of which lexicographers admit the usage, although they mark it as "low." It is presumably a corruption of *non compos*, and is defined as "a fool, a blockhead, a trifling dotard." It is nincompoop, and may it not be justly applied to that empty oracle, Mr. Nicholas Procter Burgh, even if the term exceed the limits of subderisive criticism?

LOCOMOTIVE ECONOMY.

(Continued from page 439.)

In the case of the adoption of smaller driving-wheels, as we have so often recommended, steel tyres of as great hardness as is consistent with strength should be used, and it is now known that tyres of much greater hardness than Krupp originally sent to the London and North-Western line may be safely employed. Hard steel tyres require Vickers's "special steel" tools for turning them, or they may be ground as practised by Mr. Armstrong, of the Great Western Railway, at Swindon. Care should be taken to have the engine so counterweighted that, when hung on slings, the engine shall make the smallest diagram of unsteadiness. The pistons, piston-rods, crossheads, connecting and coupling rods, and crank-pins, should all be of steel, and as light as is consistent with strength. Cast-steel pistons are already coming into considerable use, and, when fitted with Ramsbottom's rings, they need not weigh more than one-half as much as the old cast-iron pistons. The small-wheel engine, intended to work at a high piston-speed should have large and long and very carefully fitted driving-axle journals, with every precaution to prevent "knocking," and, as in all engines, it will be all the better if the friction of the valves is taken off. With all these provisions (and they are such only as should be observed with all engines), and with easy springs, hung upon rubber blocks, and connected, in the case of coupled engines, by compensating levers, it will be found that small-wheel engines will run wonderfully steady at high speeds, even up to sixty miles an hour, the piston, of 22 in. stroke, then moving perhaps 1200 ft. per minute, while its maximum speed, at mid-stroke, would of course be 1.57 times greater, or at the rate of nearly 1900 ft. per minute.

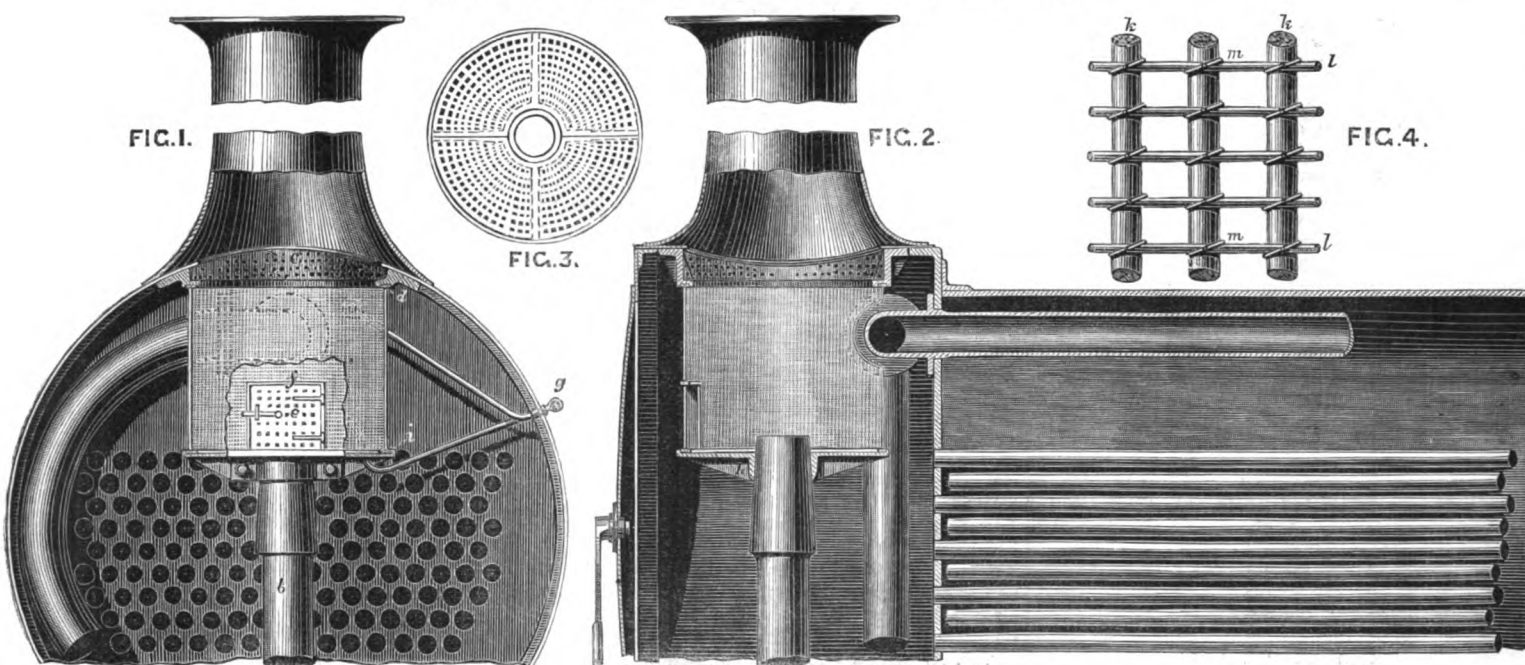
Nothing helps more to preserve an engine in good working condition, and thus to keep it out of the shops, than a clean boiler. Blowing off is not the sole preservative, and if firebricks be fitted in the firebox, as is often done now as a means of preventing smoke, it will not do to blow off under steam, even if the fire has died out, for the bricks will be quite hot enough to burn the firebox. In some cases fireboxes have been ruined in this way, and it is not improbable that the mysterious cracking of steel plate fireboxes, some of which have gone off like a pistol, when stone cold, the engine standing at the time in the running-shed or the repair-shop, may have been caused by injury done to the steel by hot firebricks at the time of blowing off. We say this, knowing of such cases of the failure of steel fireboxes, and knowing that they were fitted with firebrick arches. To keep a boiler clean, there should be plenty of hand holes and mudhole plugs, so placed as to reach what would otherwise be the most inaccessible parts of the boiler, and there should be frequent cleanings with a scraping-rod, and washing out with a hose. The Yorkshire Engine Company are fitting an excellent style of mudhole cover to their engines, where they are permitted to do so by their specifications, for all engineers who send their plans to a locomotive factory will not allow improvements to be applied. This



cover, shown in the annexed sketch prevents the burring of the thread caused by the frequent use of iron rods within ordinary mudholes, and it is also a stronger fastening. Much is expected of Baker's anti-incrustator, as now made by Messrs. Kitson and Co., and also, we believe, by Messrs. Galloway and Sons, of Manchester. This instrument, however, loses its power if the points of the "battery"

BROWN AND COSSER'S SPARK-ARRESTER,

AS APPLIED TO THE LOCOMOTIVES OF THE SCINDE RAILWAY.



become oxidised, and after plating these with copper, and then silvering and then gilding them, we learn that Messrs. Kitson are about to make them of platinum. If the "battery" can be made to keep its power, the anti-incrustator will prove the most effective agency ever known for keeping boilers clean, and it is fully ascertained that it exerts no corrosive action upon the iron, copper, or brass of the boiler itself.

We illustrate on the present page a spark-arrester as used upon the Scinde Railway, and considering how so many coal-burning engines now throw fire, it is deserving of consideration whether such a protection is not desirable upon our home lines. Barns, haystacks, and wheat are now frequently burnt by sparks from engines upon contiguous railways, and we frequently hear of luggage taking fire when stowed, under tarpaulins, upon the tops of the carriages. The American spark-arresters act not only by interception, like the wire netting shown in our illustration, but the sparks are further thrown down by being projected, with the blast, against an inverted cone over the chimney-top, the upper and larger end of the cone having a broad curved rim, like that of an inverted teacup, to throw down the sparks into a larger casing surrounding the chimney. The steam and gases rise at the edge of the deflecting cone, and escape through a wire netting, often of an area of 15 or even 20 square feet, covering the portly outer casing above mentioned. It is because of these repeated obstructions to the natural draught that the blast-pipes of American engines require to be made so small, the separate nozzle to each cylinder (for double blast-pipes are generally used) being often as small as 2½ in. for a 16 in. cylinder. Such spark-arresters as these will never be adopted upon English lines, but it deserves the fullest trial to ascertain with how little real obstruction to the draught and to the steaming powers of the engine an intercepting guard of wire-work, sufficient to throw down all but fire sparks may be used in the chimney.

Will our locomotive superintendents generally ever have the courage to try, as Mr. Adams, of the North London Railway, is now trying, chilled cast-iron wheels? They can be imported at 5*l*. only each, for a diameter of 3 ft. They are the only wheels which will stand the rigours of the Canadian winters, wrought-iron wheels of the best makes having, according to the testimony of the managers of the two great lines of Canada, Mr. Brydges and Mr. Swinyard, proved altogether inferior to them. They are the only wheels used on the Great Nicolai Railway, in Russia, even under the imperial train. It is an exceedingly difficult task for a strong man to break one with a heavy sledge-hammer, and the durability of the chilled surface is far greater than that of steel.

The locomotive engineer, indeed all engineers, should be constantly experimenting, not in great ventures into the unknown, and where failure would cause great loss of money, and possibly great loss of life, but experimenting in a smaller and quieter manner, such as

can at the same time demonstrate new and unexpected truths. There is always a world of prejudice in the way of improvement, and yet we are continually learning that what was supposed to be impossible is often found to be not only possible, but advantageous, a great deal better, in fact, than the orthodox possibilities which preceded it. There is not probably another line of railway in the world where new plans for the improvement of locomotives, and the saving of locomotive expenses, are so steadily, intelligently, and successfully experimented upon as they are on the North London line. Indeed, its locomotive department, under the management of Mr. William Adams, has become a study for the locomotive engineers of the kingdom, who there find the successful results of what they may not venture to try for themselves.

THE HASTE OF BATTLE.—Among the advantages of breech-loading military rifles mention is frequently made of the impossibility of disabling these arms by overloading. By overloading is meant not the introduction of too large a charge or of too heavy a bullet, but the introduction successively of charge after charge until the barrel is choked up to an extent little dreamed of, and perhaps deemed incredible by those who know nothing of the confusion and terror and excitement of a fierce battle. We have lately stumbled across the official report of the examination of the arms collected upon the battle-field of Gettysburgh, which we presume may be accepted as literally accurate, and which affords us such a curious insight into the condition of mind of even veteran and very gallant soldiers in a hot action, that we think the following extract is well worth reprinting:—"Of the whole number of arms received (27,574) we found at least 24,000 loaded. About one-half of them contained two loads each; one-fourth from three to ten loads each, and the balance one load each. In many of these guns from two to six balls have been found with only one charge of powder. In some the balls have been found at the bottom of the bore, with the charge of powder on top of the ball. Twenty-three loads were found in one Springfield rifle-musket, each load in regular order. Twenty-two balls and 62 buck's shot, with a corresponding quantity of powder all mixed up together, were found in one percussion smooth-bore musket. In many of the smooth-bore guns, model of 1842, of rebel make, we have found a wad of loose paper between the powder and the ball, and another wad of the same kind on top of the ball, the ball having been put into the gun naked. About 6000 of the arms were found loaded with Johnsons and Dow's cartridges; many of these cartridges were about half-way down the barrels of the guns, and in many cases the ball end of the cartridge had been put into the gun first. These cartridges were found mostly in the Enfield rifle musket." When we are told officially that at least 12,000 men fought at Gettysburgh, [who, not knowing or caring whether their muskets had gone off, rammed home a second charge, and that at least half these men went on ramming home charges, for the most part topsy-turvy, until they were shot down or could ram no longer, we are better able to appreciate the value of an arm with which such overloading could not occur.—*Pall-Mall Gazette*.

NEW TELEGRAPH CABLE.—Mr. W. T. Henley, of North Woolwich, has just completed successfully the laying of the Submarine Telegraph Company's new cable from the South Foreland to La Panne, a small fishing village in Belgium, close to the French frontier. The cable is a very heavy one, containing four conducting wires.

BROWN AND COSSER'S SPARK-ARRESTER.

We give, above, engravings of a form of spark-arrester for locomotives, designed by Mr. James Brown, of Sunderland, and Mr. Cosser, and which has been patented by them in India. In our illustrations, Fig. 1 is a transverse section through the smokebox of an engine having the arrester applied; Fig. 2 is a corresponding longitudinal section; Fig. 3 is a plan of the bottom plate, *h*; and Fig. 4 is an enlarged view of a portion of the arrester, showing the mode of fastening the wires.

The arrester is, as will be seen, of simple construction. A casting, *c*, is bolted to the top of the smokebox around the bottom of the chimney, the casting having at its underside a groove, *d*, for receiving a wrought-iron ring. The perforated bottom plate, *h*, is made in halves, bolted together round the blast nozzle by the bolts, *a a*; and it is provided with a lip, *i*, for holding the lower ring of the arrester in place. The two wrought-iron rings are connected by thick vertical wires, *k k*, the ends of which are rivetted into the rings; and these vertical rods are crossed by finer horizontal wires, *l l*, secured by binding wires, *m*, as shown in Fig. 4. A small door-frame, *e*, is fitted to the front of the spark-arrester, this frame receiving the end of the wires, which are shortened to accommodate it. When it is desired to take down the arrester, the bolts, *a a*, are removed, the bottom plate, *h*, then comes away, and the wire cage falls from the groove, *d*, and can be readily taken out.

The spark-arresters above described have been applied to engines on the Scinde and Punjab Railways, and Mr. John Brunton, the chief engineer of the Scinde Railway, speaks very highly as to their efficiency, and states that, since their adoption, but very slight damage from fire has occurred on the line, notwithstanding the large quantities of cotton and other inflammable materials constantly passing over it. The arresters are also being applied by Messrs. Robert Stephenson and Co., of Newcastle, and Messrs. Kitson and Co., of Leeds, to a number of engines now in course of construction for the Delhi Railway. It is stated that the arresters do not interfere with the draught, nor increase the consumption of fuel.

FESTINIOG ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—Your recent article under above heading states that "Mr. England was employed under Mr. Spooner to design and "construct an engine," &c. Will you kindly correct this, as the engines were constructed by Mr. England, under my supervision and control, and according to my design? I also advocated the original adoption of the locomotives on the 2 ft. 1 in. gauge.

I am, yours truly,

Tan-y-Bwlch, Carnarvon,

Nov. 9, 1867.

CHARLES M. HOLLAND.

THE PARIS EXHIBITION PRIZE MEDALS.—The *Moniteur* announces that the gold medals for exhibitors will be ready for distribution between the 15th and 20th of November, the silver medals from the 5th to the 31st of December, the bronze medals from the 15th of January to the 29th of February, 1868. The diplomas will be distributed with the medals, and the "mentions honorables" will be given from the 1st to the 31st of March, 1868. In classes 52, 70, 71, 74 to 82, 83 to 88, and 95 the list of awards will be at once printed provisionally for rectification, and reprinted finally, and the lists of awards in musical composition and pleasure boats and yachts will also appear shortly. Each medal will be specially struck with the name of the donee, and, as about 16,000 will be needed, there has been some time, and will be more, needed to turn out such a large coinage.

PRE-ADAMITE LOCOMOTIVES.
 CONSTRUCTED AT THE NEATH ABBEY WORKS, SOUTH WALES :—1831.
 (For Description, see Page 457.)

FIG. 1.

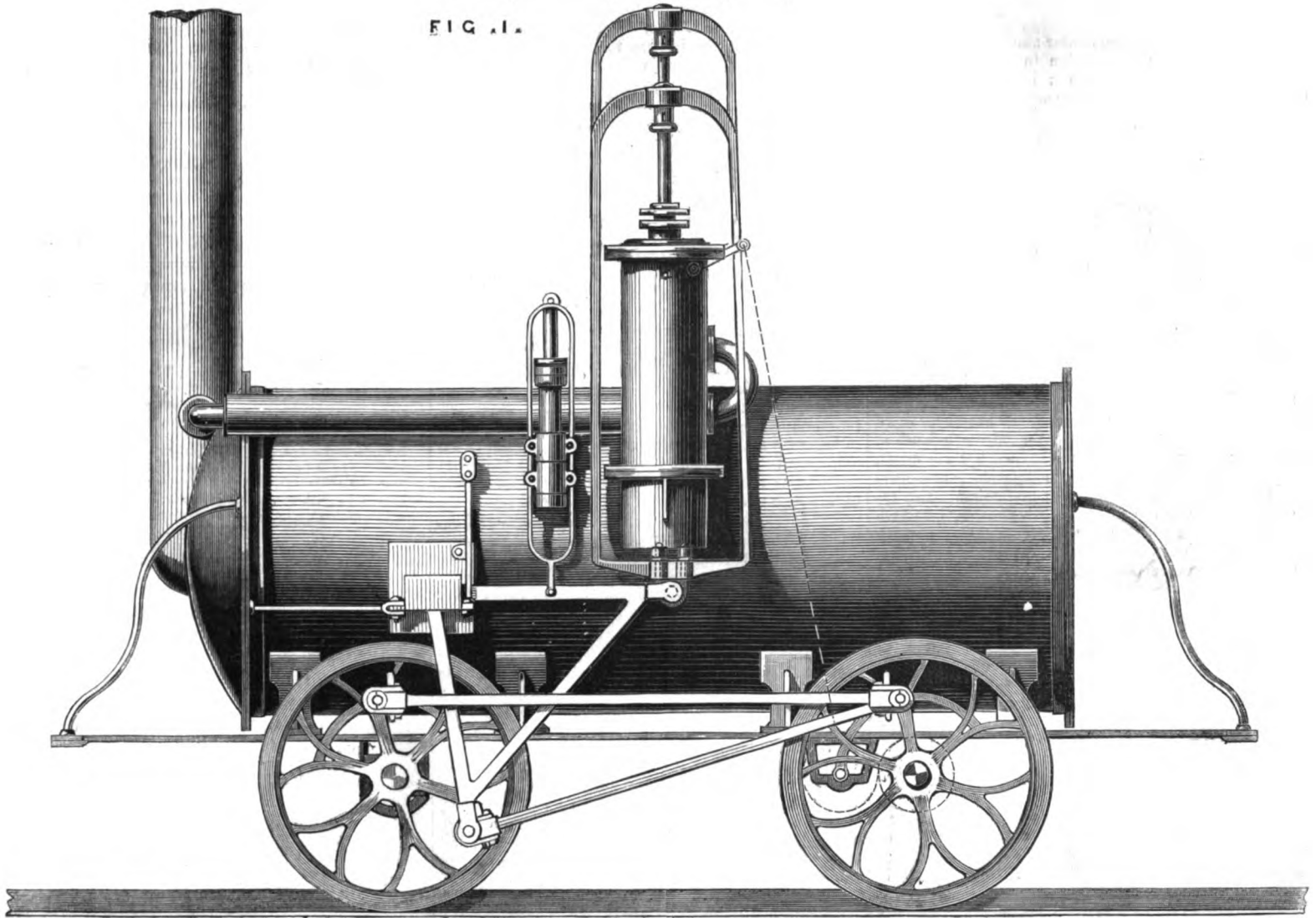
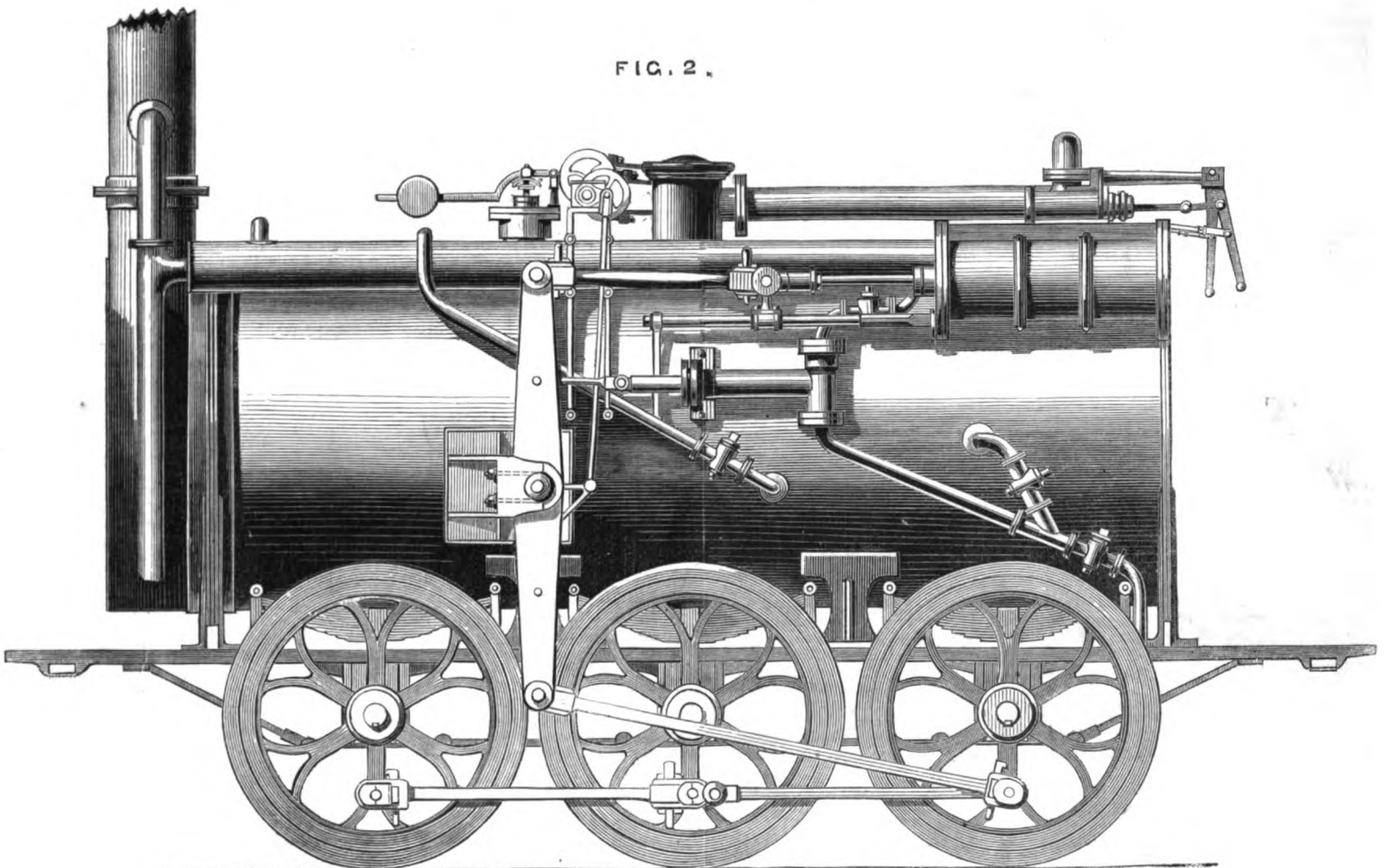


FIG. 2.



LITERATURE.

Modern Marine Engineering. Illustrated with thirty-six correctly coloured Plates and two hundred and forty Woodcuts. By N. P. BURGH, Engineer. 4to, pp. 403. London: E. and F. Spon, 1867.

THIS work is indeed a phenomenon. We had little expectation, judging by Mr. Burgh's previous productions, that we should encounter much depth of knowledge or felicity of expression in his present utterances. But we thought it not impossible that time and experience would bring some improvement, and certainly we were not prepared for the profundity of bathos that we have here encountered. Of the plates and cuts, which are illustrative of the practice of different makers in the construction of marine engines, we need not here say anything, as the good or bad qualities they exhibit, whatever they may be, must go to the credit of the different designers, and Mr. Burgh is no more to be praised or blamed for having been the medium of putting these drawings into print than the printer or his imps. But for what he has written with his own pen, whether in the way of thesis or commentary, Mr. Burgh is clearly responsible; and by this criterion alone we have to consider the merits of his present performance. Taking, then, Mr. Burgh's own part of the work, and weighing it in the scales of impartial criticism, we must say that a more ridiculous and puerile production it has never been our lot to wade through. Here have we a work of considerable pretension running to over 400 4to pages, and professing to be capable of enlightening engineers on an important branch of their profession. Yet, except in so far as the drawings are concerned—which are not Mr. Burgh's at all—we encounter nothing from the beginning of the work to the end of it, except the stalest truisms expressed in the clumsiest and most ungrammatical language; and the main sentiment excited in the reader is one of amazement, that in this nineteenth century a man of so shallow a mind, and so destitute of even the most ordinary educational attainments, should have the effrontery to set himself up as an instructor of engineers. To those who have not gone through the ordeal of decyphering Mr. Burgh this may appear strong censure. But we propose to enable our readers to judge whether it is not fully merited, by laying before them such extracts illustrative of the "beauties of Burgh" as our limits will allow. It is very little consequence where we begin, as all is alike transcendent. But we may take a specimen from the beginning of the work, which was probably elaborated with extra pains. We think we are entitled to ask who the engineers are that are likely to be informed or gratified by such profound, relevant, and graceful exposition as the following?

"The adoption of Steam as a means for navigation was undoubtedly a great advance over that of manual and wind power; the former is weak, while the latter is capricious. Marine Engineering of the present day may be said to embrace many branches. For the present purpose, that portion applying to Paddle and Screw Propulsion will only be dealt with. Much has been written on this subject; volumes of historical facts have been published. The names of Farey, Tredgold, Bourne, and others have almost become household words in allusion to the history of the Steam Engine. The leading periodicals too have not been free from the contagion of relating past events. In such works as these can be found every requisition to satisfy the most vigorous, lusting after chronological events of steam as a motive power. This having been well digested by others, it will be sufficient for the present purpose to touch but lightly on the practice of even twenty years ago. What seems to be required in the present day is a work that shall carefully investigate the subject it treats in detail; not alluding to each part singly, but to the many recognised actual details produced by the several makers. It may be said that previously this could not be attained, due to the fact that the manufacturing powers were slow in imparting or permitting information of practical utility. This want of confidence and idea of preserving much to gain nothing, is now happily becoming rare, and we find that the most eminent firms are the least suspicious of dishonour in those they trust. With this assurance of a certainty, the present work will treat of facts; assumptions will only be introduced for the purpose of proving the truth of natural laws. For practical purposes a work should allude to many details of the same nature. It is found in every-day life, that every portion of our existence has a motive; in like manner, each scheme or invention has its advantage. The mechanical portion of the profession is daily on the increase, the engineers and naval architects, that were once learned in stone and wood, bend with grace to the iron age of truth. Our forefathers sneered at the proposition of floating iron steamships, and it is not long since that wise heads shook with condemnation at a vessel coated with nine inches of plating on her hull; what was deemed a fallacy is become a living illustration that nature cannot lie. The positions of many of the most essential details of a marine engine are often unknown to the student; his knowledge extends perhaps to the cylinders and condensers; he may doubtless know a little of the valve-link motion, but the mode of converting an ordinary engine into an expansive production he will halt at. Little or nothing possibly he knows, too, of surface-condensation and superheating, while the many arrangements are entirely hidden from his conceptive powers. The commencement of a young engineer is generally an

epoch in his life, filled with enthusiasm he is ingenious in the extreme, which is worthy of a good cause. Doubtless the ideas of others being before him prompts originality, and, what is often the case, emanates discarded facts."

The same species of drivel is distilled through a great number of dreary pages, and the reader who is courageous enough to wade through them is as incapable at the end as at the beginning to make out what they are all about. We fear it must be a law of Mr. Burgh's nature that whatever he has to say he will inevitably say very badly. But the main secret, we take it, of his want of illuminating power is his complete destitution of ideas. It is remarkable that a man so singularly incapable should be willing to make a spectacle of himself before the world. But just as there are lunatics who, on the strength of possessing bits of glass and ribbon, look upon themselves as kings and princes arrayed in untold grandeur, so Mr. Burgh presents evidence that there are authors who, on the strength of possessing a few drawings, rush into print and straightway suppose themselves engineering authorities, not discerning the laughter provoked by their want of sense and want of modesty.

We think that those who have had virtue enough to get through the foregoing extract will conclude that the language of philosophic reflection does not fall happily from Mr. Burgh. Nor is he one whit more successful when he proceeds to unfold the mysteries of special departments. Thus, in the dissertation on heat and combustion, he thinks it necessary to begin by informing us of the truth, no doubt in his judgment little appreciated, that "the cause and effect of heat is a subject worthy of consideration;" and having enforced this maxim, he proceeds to say that "the cause of latent heat undoubtedly emanates from nature." Of combustion and friction, he says that "the former may be said to be a natural production, while the latter is an artificial attainment," and that "when heat is caused by friction it is in general unintentional." He proceeds to inform us that "the higher the temperature of any gas or vapour, the less its density," from whence it would follow that high-pressure steam is less dense than low; and he adds that "the time of conduction of any material is not a matter of universal consideration. It is too often forgotten that the nature of the appliance is the chief portion worthy of attention when practical results are required." We need not, however, multiply these profound observations, which are continued through a great many pages. Let it suffice to say that, like the oracle within the empty cask, it will sorely try the reader's penetration to discover what is meant, and after the discovery has been made, it will be found to be a platitude or self-evident proposition, the recognition of which will be small reward for the labour expended in finding it out. Other authors think it a merit to be intelligible, and to enable their readers to understand in the fewest and clearest words what they mean. Mr. Burgh's, however, is the inverse process, and, having nothing worth telling to communicate, seeks to conceal the poverty of the land behind a heap of incoherent verbiage. He is hence signalled by the art of saying nothing in a great number of words, which have neither sense nor sound.

The question of the comparative merits of different constructive details in engines and boilers is a topic requiring for its efficient treatment much and varied knowledge and perfect freedom from bias, joined with courage and sincerity. It is needless to say that Mr. Burgh has none of the qualities necessary for the discharge of this judicial function; nor can we believe that engineers of competent attainments would be content that their confession of faith should be travestied by so weak and wordy a commentator. It would occupy too much space here to introduce specimens of Mr. Burgh's method of description, and of the wise saws he utters; but our readers will have no difficulty in understanding that their quality is about the same as that of the rest of his performance.

Mr. Burgh concludes his work with a chapter on the principles of the marine engine, in which there is not a point of information which has not already been presented in previous works, and with which consequently engineers are already familiar. The language, however, is unquestionably Mr. Burgh's own, and, as a specimen of it, we shall content ourselves with citing the following passage, with which the chapter begins:

"To set aside the principles of any subject is similar to building a structure without knowing the status of the foundation; it is also apparent that the 'origin' of any effect is due to the cause; the main question, at present, however, is the best means of arriving at the truth of certain results, and at the same time to 'break ground' for further improvement.

"The 'marine engine,' as it is at present, consists of a sliding action imparting motion to a pin which revolves around the axis

of suspension or support, and therefore the first subject refers to the actual difference in the speed of the piston and crank-pin at equal positions on the centre line of motion."

We think we must now have convinced even the more sceptical portion of our readers that the censures we have pronounced upon Mr. Burgh's incapacity are in no degree unmerited. That any man, woman, or child should be found, in this enlightened age, to flash in our faces such penny wisdom as, that to set aside the principles of any subject, is like building a structure without knowing the status of the foundation, that the origin of any effect is due to its cause—and that the marine engine, as it is at present, consists of a sliding-action, may certainly provoke our surprise. But when the author of these erudite maxims sets up as an instructor of engineers, there is no alternative left to us but to suppose either that we are all more ignorant than we had thought, or that we have encountered an author who is not only destitute of all ordinary gifts, but has not even the saving grace of moral fear.

ECONOMIC SPANS OF VIADUCTS.

TO THE EDITOR OF ENGINEERING.

SIR,—The following result, as to the most economical spans for a viaduct of given height, may perhaps be of interest to some of your readers.

Call L the total length of viaduct; P , the cost of a pier, supposed to be the same whatever the span; S , the cost of the superstructure of one span; and x , the length of the most economical span required, meaning by span, in this case, the length from centre to centre of piers.

Because when $x=0$, $S=0$, we may assume for S an expression of the form $S=Ax+Bx^2$, where Ax is the cost of all that part of the superstructure which remains the same whatever the span: for instance, cross girders, planking, &c., in an iron bridge; parapets, &c., in a stone or brick bridge; and planking and handrail, &c., in a timber bridge. Bx^2 is that part of the cost of the superstructure which varies as the square of the span; such as, speaking roughly, the cost of the main girders or trusses in iron or timber bridges, and the cost of the centring and part of the masonry in stone bridges.

Then the number of spans will be $\frac{L}{x}$.

the number of piers will be $\frac{L}{x}-1$.

And the total cost of the viaduct, putting C for the cost of the abutments, will be

$$\frac{L}{x}(Ax+Bx^2)+\left(\frac{L}{x}-1\right)P+C,$$

$$\text{or } LA+LBx+\frac{L}{x}P-C,$$

which is to be made a minimum.

Equating the first differential coefficient to zero, we get

$$LB-\frac{LP}{x^2}=0.$$

$$x^2=\frac{P}{B} \text{ and } x=\sqrt{\frac{P}{B}}$$

Putting this result in the form,

$$Bx^2=P,$$

it appears that when the cost of a viaduct is a minimum, the cost for one span of that part of the superstructure which varies as the square of the span is equal to the cost of a pier.

Approximate values of P and B can hardly be given, as they will vary with situation, nature of materials of piers and superstructure, load the viaduct has to sustain, &c.; but when these particulars are known, the values of P and B can easily be determined in each particular case. The viaduct being supposed to consist of equal spans, the value of P must be taken from the mean sectional height; but if the ground slopes or undulates considerably, so that the height varies, the value of P may be taken for any particular height, and the span, x , as above determined, will then apply to that height, so that the viaduct may be made of different spans to suit its varying heights. If, instead of assuming P to be the same for all spans, it be assumed to vary to some extent with the span, it will be easy to substitute $P=Q+Rx$ for P in the above investigation, and the value of x will be modified accordingly. But it will probably be hardly worth while to go to such minuteness, because when a function is at its minimum the value of the variable may be altered to some extent without sensibly affecting the value of the function; so that the span, as found above, may be either increased or diminished slightly, and in some cases considerably, without thereby materially increasing the total cost.

W. B.

SUEZ.—It is stated that the British Government proposes to establish between Suez and India a service of steamers to be specially devoted to the conveyance of its military contingents. The present transport, *via* the Cape of Good Hope, conveys about 17,800 men—12,100 going out and 5700 coming home—annually, and involves an expense estimated at 360,000*l.* It is calculated that the new route would reduce the numbers of the contingents conveyed to the extent of about 2000 men annually, and that it would save 120,000*l.* in the transport expenses. Agents charged with the inspection of the passage of English troops across Egypt have arrived out, a special hospital is being constructed at Suez, and the naval plant comprising five screw steamers is expected to make its appearance shortly.

RAILWAY MATERIALS.—The Great Northern and Midland Railway Companies are advertising for their usual stores of iron for next year, and there is a contract in the market for the supply of 14,000 tons of rails and 5400 tons of chairs, with the necessary fish-plates, bolts, and spikes, for the East Indian Railway Company.

HOT-AIR ENGINES.

MANY attempts have, from time to time, been made to introduce into general use engines worked by hot air, but so far with but comparatively little success. In America there are, we believe, now some hundreds of small hot-air engines, constructed on Ericsson's ingenious but somewhat complicated plans, in regular work; but in this country they have never met with much favour. Notwithstanding this, however, the hot-air engine might probably, in some instances, be very advantageously substituted for an engine worked by steam, and this is particularly the case when the power required is but small. The great objection to steam-engines of very small power is, that the cost of superintendence of the boiler and machine forms a very important item in the total cost of working. In some instances this has to a great extent been got over by the use of gas as a fuel for heating the boiler, as in Mr. Arthur Jackson's neat gas-heated boilers, which we described in our last volume (*vide* page 197); but still there are some persons who would prefer doing away with the boiler altogether, on account of the space occupied by it, and for other reasons—and this the use of hot air as a motive power enables them to do.

Amongst the forms of hot-air engines recently introduced, is that which has been brought forward during the past year by Messrs. Edwards and Co., of 531, Oxford-street, and of which a number are now in work in London, giving very satisfactory results. This engine is of very simple construction. It is single-acting, and the cylinder is placed in a vertical position on the top of the furnace or air-heating chamber. This chamber is a strong cylindrical cast-iron vessel lined with fireclay segments, and fitted with a fire-grate. The fuel is placed on the grate through a fire-door, which can be closed air-tight, and the air for supporting combustion is forced into the lower part of the chamber below the grate by an air-pump, as will be explained presently. Flues fitted with dampers are provided; so that the air forced into the chamber below the grate can, if desired, be allowed to pass to the upper part of the chamber, without passing through the fire, and this arrangement enables the temperature of the air supplied to the engine to be regulated. The products of combustion and the heated air are conducted by a pipe from the upper part of the heating-chamber to the valve by which their admission to the cylinder is regulated. The valve, as well as the exhaust-valve, is worked by fingers on a rocking-shaft, which has a reciprocating rotary motion imparted to it by an eccentric on the crank-shaft.

The piston, which is packed with a leather packing-ring, is made in a deep trunk form, and the packing is placed around the upper end of the trunk. The effect of this arrangement is, that the heated air before coming into contact with the packing has to traverse the narrow annular space between the trunk piston and the cylinder, and it thus becomes too much cooled down to affect the packing injuriously. It is stated that a leather packing-ring, thus applied, will last from three to four months in regular work. The piston is fitted with a rod working through a guide, and it is connected, by a pair of links, with the one end of a double beam vibrating on a centre, carried by a standard fixed to the cylinder. The other end of this beam is coupled to the crank-shaft by a connecting-rod in the usual way, and it is also connected, by a pair of rods, with the air-pump piston. The air-pump, which is single acting, is placed on the base-plate, close to the furnace, and it communicates with the latter by suitable passages. The air-valves are ordinary leather flap-valves, and provision is made for allowing some of the air passing through the pump to escape, if required, instead of being forced into the heating-chamber. This arrangement enables the power of the engine to be varied.

The action of the machine is as follows: The fire being lighted, and the fire-hole and ash-pit doors being closed air-tight, the fly-wheel is turned two or three times by hand, and a certain quantity of air thus forced by the air-pump into the heating-chamber. A portion of this air is utilised in supporting combustion, whilst another portion is simply expanded by the heat, the effect being that sufficient pressure to drive the engine is soon accumulated within the heating chamber. The hot air is allowed to act on the underside of the piston during nearly the whole of the up stroke, whilst during the down stroke the opening of the exhaust-valve allows of its free escape from the cylinder into the atmosphere. An ordinary stove pipe serves to conduct away the waste air, which latter may, if desired, be used for heating purposes. It will be seen that the up stroke of the piston is caused by

the pressure of the air on its under side, whilst its down stroke is due to the momentum stored in the fly-wheel. During the up stroke of the main piston, the air-pump piston is performing its down stroke, and is thus forcing into the heating-chamber a fresh supply of cold air, which is in its turn expanded and admitted into the main cylinder. The effective force exerted during the up stroke of the main piston is, of course, that due to the difference in the total pressures on the under sides of the main and air pump pistons respectively—a difference due to the difference in the areas of the two pistons, as the pressure per unit of area is, of course, the same in both cases.

There are, as we have stated, now a number of these engines in use, and we believe that they perform their work very economically. The consumption of coal per horse power developed is probably greater than in a well-constructed steam-engine; but, on the other hand, the cost for attendance is much less, and this, in the case of small engines, is generally the more important matter of the two. As to the general design of the engine, we must say that it is capable of much improvement, and it is probable that the space taken up by the machine, though even now far from great, might be considerably reduced. It is, we think, a pity that the makers of the engine do not carry out a complete series of experiments in order to determine accurately the capabilities of the machine. Indicator diagrams should be taken, the consumption of fuel and the temperature and pressure of the air accurately noted, and the actual power developed measured by the friction brake. The results of such a series of carefully conducted experiments would, if favourable, do much to establish the value of the engine, and we therefore trust that they may be carried out. We have said that the general arrangement of the engine is open to improvement, and this improvement will, no doubt, soon be effected; but, even in its present form, the engine is well worthy of the attention of all requiring engines of small power.

STEEL RAILS.

We clip the following profound observations from the *Iron Trade Review*, and we have given an answer to them on page 469.

TO THE EDITOR OF THE IRON TRADE REVIEW.

SIR,—The editor of *ENGINEERING*, a paper which I readily admit to be conducted with much energy and ability, seems to be going out of his way a good deal of late, in order to write down the iron trade and to push Bessemer steel into universal use. I admire the invention which Mr. Bessemer has so successfully worked into a practical form, and I admit that for many purposes this material can be advantageously used where iron was formerly employed; but I cannot allow that for rails, for instance, the advantages are so greatly in favour of steel. We hear much talk about a few picked rails put down as tests, in certain places where there is particularly heavy traffic, but nothing is said of broken steel rails and others which have not answered expectation. It has yet to be proved also how the traffic would be impeded by the smoothness of a line composed entirely of steel rails: my impression is that the engine wheels would slip very much. One thing seems clear, however, and that is, manufacturers of steel rails do not appear to have yet made them except at a considerable loss. What with impurities in pig iron, necessitating a long manipulation in producing the steel, and also the loss of crop ends which have not yet been turned to much account, and other causes, I do not think that the iron trade need be afraid about the future demand for iron rails keeping up. It will be a long time before steel rails can be extensively adopted, if ever the good things said about them prove correct; and as the price of Bessemer steel may be expected to increase considerably, probably several pounds a ton, in the next few years, I think it will be found that this industry will not undergo much extension at present, and that the steel rails used will be for special and not for general purposes. I have heard it hinted that the paper alluded to has very substantial reasons for writing up the Bessemer steel trade. How true this I cannot pretend to say; but certainly it does seem that the influence of the journal is shown almost entirely on the side of this particular manufacture.

I am, Sir,

Your devoted Servant,
London, November 9, 1867. Z.

THE AZIZIEH STEAM NAVIGATION COMPANY.—It is stated that at a meeting of the council of administration of the Azizieh Steam Navigation Company recently held at Cairo, the plan of establishing a regular line between Alexandria and Venice, put forward by the Viceroy, and contracted by Pini Bey with the town of Venice, was rejected. The belief appears to be that such a line, even with a subvention of about 40,000*l.* on the part of the Viceroy and the municipality of Venice together, would leave a loss of more than 35,000*l.* a year. This Azizieh Company was created in Egypt under the special auspices of the Viceroy some three years back, and the shares are now at about 50 per cent. discount. The Egyptian Government, however, have guaranteed an interest of 7 per cent. per annum on the shares, and as the Viceroy himself is a holder of more than half the paid-up capital of 1,500,000*l.*, it seems to be hoped and expected that he may soon feel inclined to buy them all up and manage the company by himself.

GERMAN IRON MANUFACTURES.

(From a Correspondent.)

DUSSELDORF, Nov. 8, 1867.

THE ironmasters and forge-managers of Western Germany have an association which meets once a year for reading and discussing papers. This year's meeting is to be held at Deuz, on the 10th instant, and is expected to have more than usual interest, since the results of the Paris Exhibition are on the list of papers. There have been some improvements in blast furnaces recently made by M. Lürman, engineer, at the Georgs Marienhütte, in Hanover, and patented in France and England. They consist in closing the cinder-hole and the space usually left open above it, allowing slags and metal to accumulate together until tapped. Trials have been made with some furnaces, and are said to have shown considerable advantages. The mining engineers and ironmasters of the district just named, at one time subjects of the independent kingdom of Hanover, are under Prussian rule at present, and they must now bring their practice into conformity with the rules prescribed by the new paternal Government. The old staff of engineers, foremen, miners, and other employees are expected to pass muster and examination before the new authorities, to determine whether they are fit for the positions which they have held perhaps for a quarter of a century past. Fancy a youngster in a blue uniform going down to Dowlais, and inviting Mr. Menelaus to pass an examination in geometry and theoretical hydraulics, to determine whether he is fit for the position he holds! The Bessemer process is the great topic of the day here, as it is in England. It is carried on at numerous works, but not everywhere with equal success. At Krupp's works, in Essen, it stands at the highest point of practical success. The Bochum Works, somehow or other, are less successful in managing their converters; they are unable to use some marks of iron like that of Mr. Wintzer's make, which has in most other German Bessemer steel works obtained a great celebrity. At Hörde Iron Works the present plant of two three-ton converters is to be doubled in extent, and the necessary pig iron is made on the spot from ores carried a great distance and at considerable expense. At works recently started, but now in full operation, the Königin Marienhütte, near Zwickau, in Saxony, they have two three-ton vessels; but the material used for lining these is of a very inferior kind. It is a kind of kaolin found at Eisenberg, near Jena; and its rapid destruction has necessitated the construction of a duplicate converter, which is placed upon the trunnions by an overhead travelling crane, after removal of the first converter, such an exchange being required almost after each change. This is a costly and inconvenient affair, which, however, has been so far successful as to enable these works to make five or six charges a day with their existing plant. Another peculiarity of these works is the testing of the quality of steel by the colour of the slags. The iron used at these works is the make of the adjoining blast-furnaces, and mixed to a certain per-centage with iron from M. Wintzer's works. Both these marks have the peculiarity of evolving an extraordinary amount of white smoke towards the end of the charge, which makes the changes of the flame almost invisible, or, at least, very difficult to watch. The workmen have been driven by despair to adopt another mode of testing the progress of the charge than the observation of the flame. They insert a testing-rod of iron into the converter, and allow a small quantity of the converter slags to collect upon the rod. At the early stages of the process the slag, when solidified, shows a rough and dull surface covered with little metallic pearls; but at the later stages the surface of the slag is perfectly smooth and uniform, taking a colour of yellowish brown when the harder kinds of steel are arrived at, and gradually passing through darker and darker shades into a bluish black. They use no spiegeleisen at these works, and so the testing-rod has become their sole and principal guide, and it is so reliable that out of one hundred charges no more than two or three have been masses. The test is finished in less than half a minute, as the slag solidifies almost instantaneously. M. Wintzer will read a paper on these slag tests at the meeting in Deuz, and exhibit some samples of slags in illustration of it. Another works very nearly ready to commence blowing is the Maxhütte, near Heildorf, in Bavaria. This has been planned and erected by Mr. Hall, a Newcastle man, who has acquired some knowledge of the Bessemer process in Austria. He teaches any parties unacquainted with the mysteries of that process, for a fee of 500*l.*, furnishing them with drawings of converters and other machinery, and with a batch of workmen for carrying out the operations. Messrs. Jacobs, Haniel, and Huyssen, in Rhinish Russia, have also made arrangements for erecting Bessemer steelworks. They have engaged M. Angerstein, who professes to know enough about the Bessemer process to pull them through all difficulties without any assistance from Mr. Bessemer or anybody else. Their principal difficulty will, however, consist in making their own iron to suit the converter, as the great bulk of their ores is of a doubtful character. At Königshütte, in Prussian Silesia, they have, after many failures and long experimenting, ultimately succeeded in working with eminent success. They bring the liquid iron direct from the blast furnaces to the converters by means of large ladles placed on trucks. They add spiegeleisen to their charges, and they have been amongst the few foreign customers for Mr. Henderson's ferro-manganese, which they will make for themselves in future, as they cannot get any more of this material from England.

THE PARKHEAD FORGE.—We have to correct some misprinted figures in our article on the Parkhead Forge, on page 336 of the present volume. In speaking of the puddling furnaces and charges, the sentence printed, "they are charged into the puddling furnace in 24 cwt. charges, and each charge produces about 1 ton," &c., should be, "they are charged into the puddling furnace in 4 cwt. charges, 24 cwt. producing about 1 ton," &c. The speed of the rolling-mill should be 33 revolutions per minute, and that of the engine 32.

PRE-ADAMITE LOCOMOTIVES.

CONSTRUCTED AT THE NEATH ABBEY WORKS, SOUTH WALES:—1838-40.

(For Description, see opposite Page.)

FIG 5

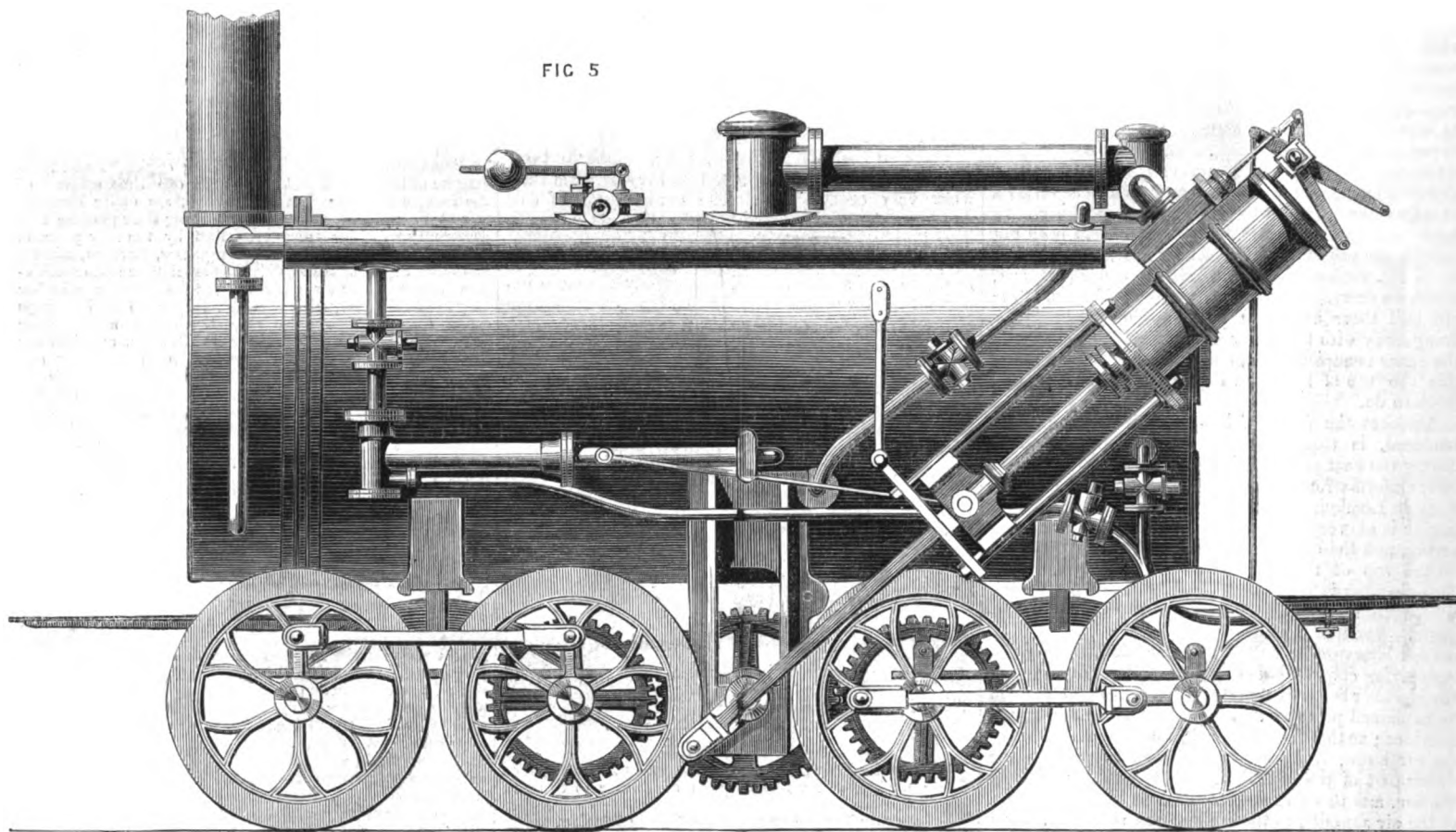


FIG. 6

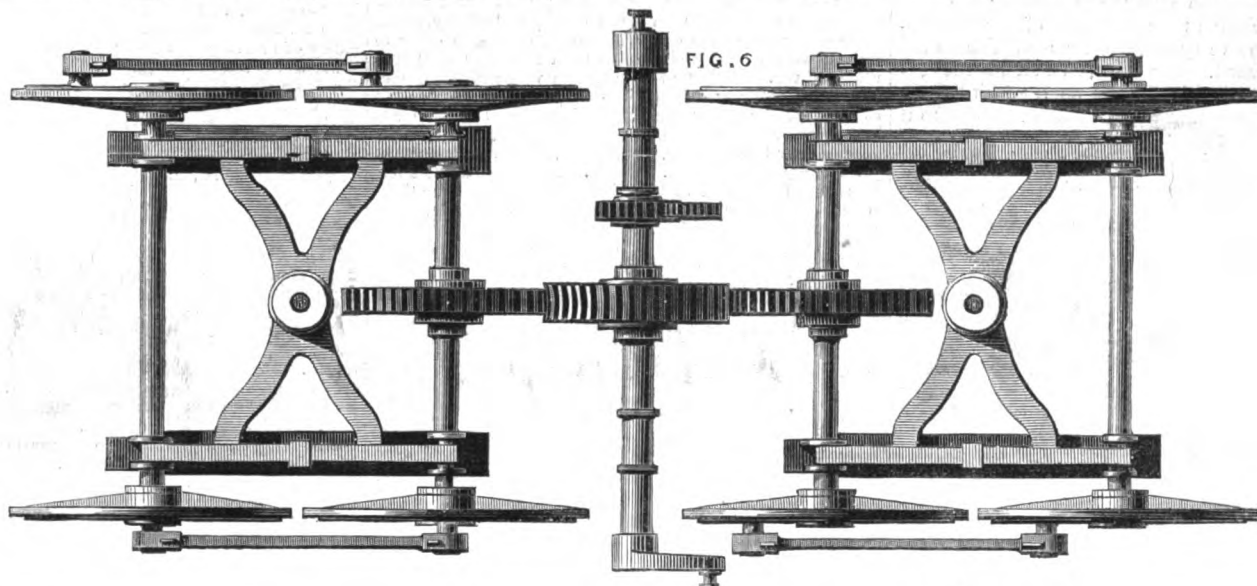
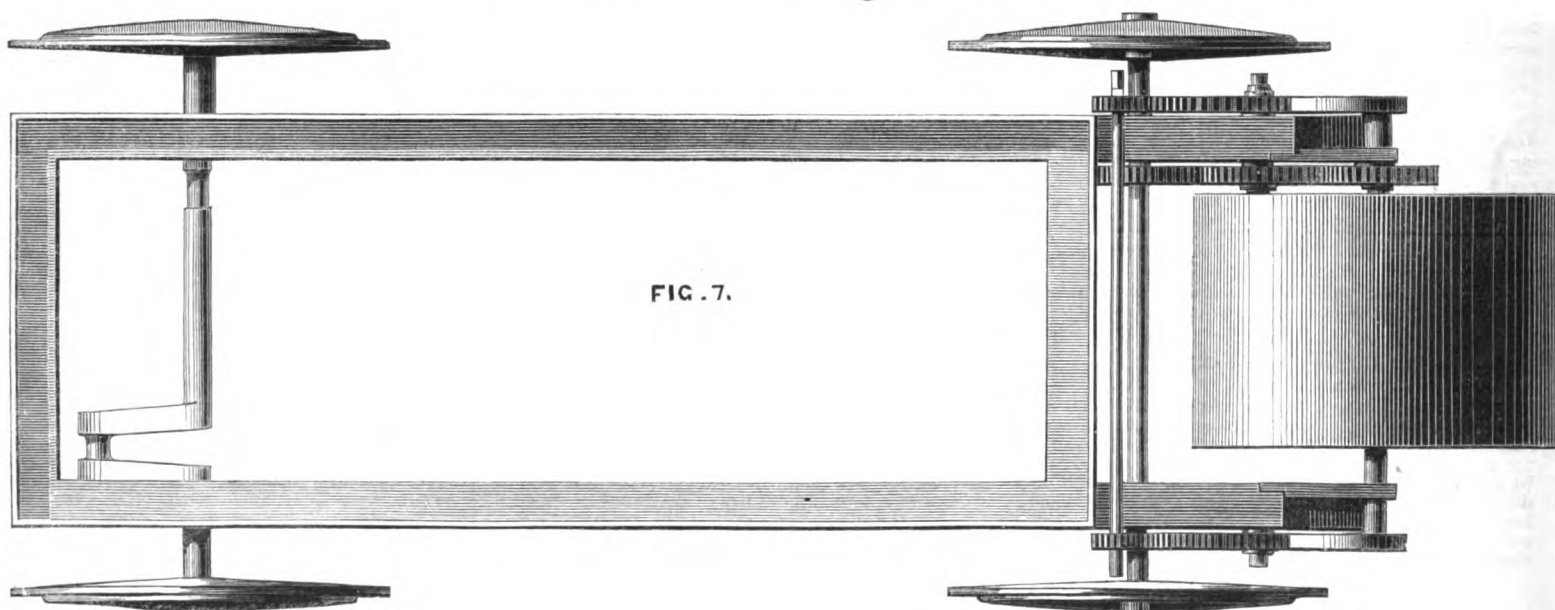
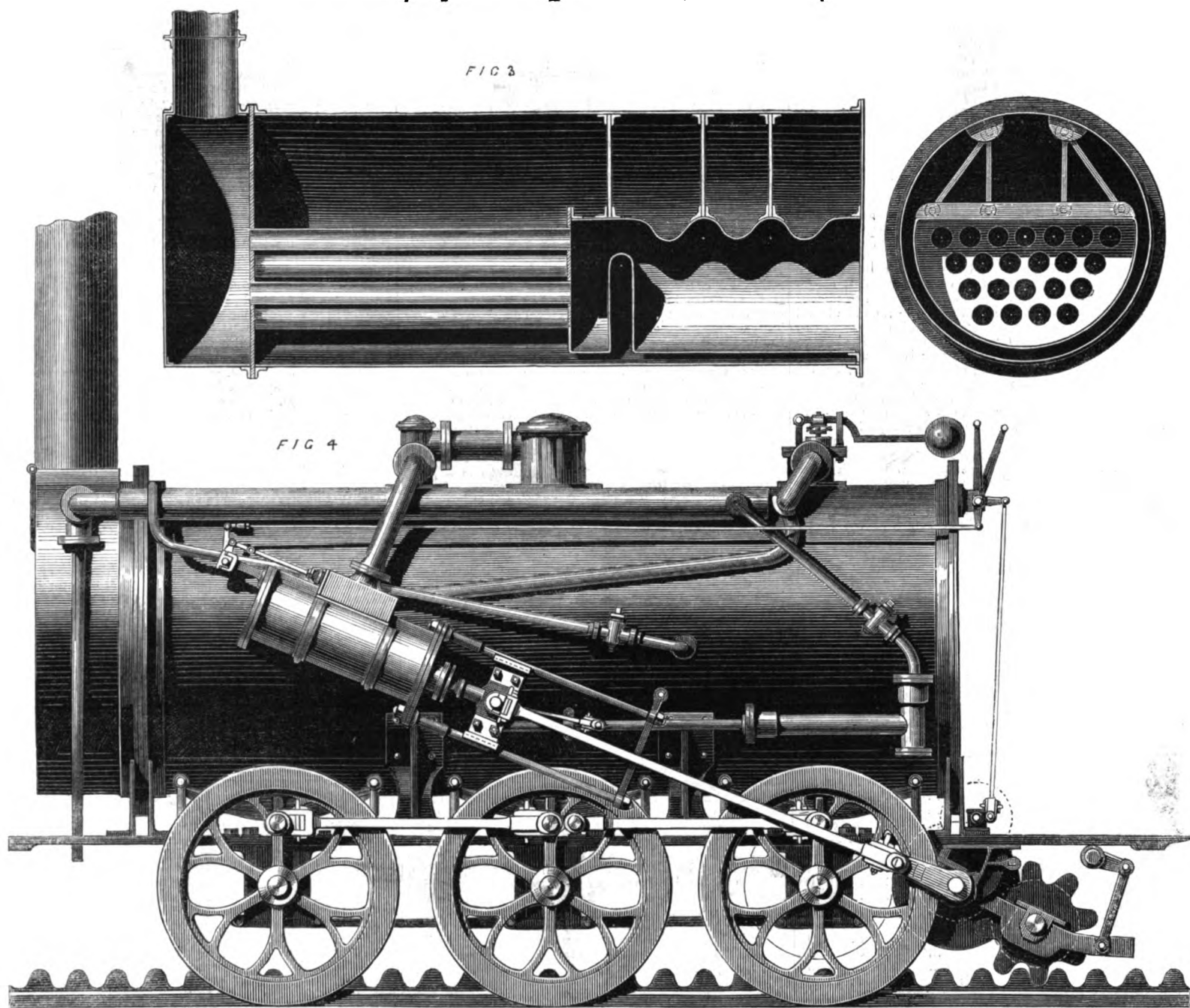


FIG. 7.



PRE-ADAMITE LOCOMOTIVES.

CONSTRUCTED AT THE NEATH ABBEY WORKS, SOUTH WALES:—1831-36.



ONE of the chief objects of a journal like our own is to lay before its readers accounts of the most recent novelties in engineering science, and our pages are consequently generally occupied by descriptions of new processes and inventions, or of important works in progress or lately completed. This week, however, we have departed somewhat from our usual course, and have devoted considerable space to recording some of the productions of bygone days, in the form of some curious locomotive engines, constructed by the Neath Abbey Iron Company, between the years 1831 and 1840. These engines, which we illustrate by engravings on the present page and pages 453 and 456, present a curious appearance to locomotive engineers of the present day, and they certainly form a most striking contrast to the engines now in general use. Notwithstanding their many faults, however, these "ancient Britons," as they almost deserve to be called, will, we think, be studied with much interest by very many of our readers.

The engine shown by Fig. 1 (page 453) was constructed by the Neath Abbey Iron Company in the year 1831 for Mr. Thomas Prothero, of Newport. The arrangement employed on this engine for communicating the motion of the pistons to the wheels is very peculiar: it will be readily understood from the engraving. Another noticeable feature is the feed-water heater, which consists, as will be seen, of a casing surrounding the horizontal portion of the blast-pipe. Fig. 2 represents another engine constructed in 1831. In this case the cylinders are placed horizontally; but they are fixed to the upper part of the boiler, and the motion of each piston is communicated to the wheels by a rocking beam. Arms projecting from these beams are connected to cranks on a shaft extending across the top of the boiler, and on this shaft the eccentrics for moving the slide-valve are placed. It will be noticed that this engine is carried on springs, and that, like that shown by Fig. 1, it is provided with a feed-water heater. The locomotive boiler shown by Fig. 3 on the present page was also made in 1831. Its construction will be clearly understood without any special description.

Fig. 4 represents a locomotive constructed for the Dowlais Iron Company in 1836, this engine being specially intended for steep gradients, and being provided with gearing for working in a rack. It is a six-coupled engine with inclined cylinders, the connecting-rods being coupled to cranks on a shaft situated under the hind end of the boiler. This shaft drives the trailing axle by means of gearing, and it is also connected by gearing with a shaft carrying the cranks for working the valves, and with another shaft on which is placed the large pinion gearing into the rack. An arrangement is provided for lifting this pinion out of gear with the rack, when required.

Figs. 5 and 6, on the opposite page, are probably the most interesting of the series. The engine represented by them is one constructed for the Rhymney Iron Company in 1838. As will be seen by the figures, the engine is carried on two bogies, each having four coupled wheels, and motion is communicated to these wheels from a shaft between the bogies by means of toothed wheels with spherical faces, as shown in Fig. 6. It will be seen from Fig. 5 that in each bogie one spring on each side is made to serve for the two axles—a plan used long afterwards by Sir Daniel (then Mr.) Gooch in some engines designed by him for the Great Western Railway.

The last figure (Fig. 7) shows a method of increasing the adhesion of a locomotive by providing it with a broad roller bearing upon the surface of the ground between the rails. This plan was applied by the Neath Abbey Iron Company, in the manner illustrated, to a small locomotive, in the year 1840. In conclusion, we should state that our engravings have all been carefully prepared from tracings of the original drawings of the various engines, with which we have been kindly supplied by the Neath Abbey Iron Company.

AN AMERICAN EXHIBITION.—It is proposed to hold a great exhibition in the United States in 1876. Mr. Horace Greeley suggests that the exhibition should be opened July 4, 1876, which would be the hundredth anniversary of the declaration of American independence.

THE PROPOSED ABYSSINIAN RAILWAY.—No railway has yet been determined on; but particulars of Mr. Haddan's pontoon railway have, we believe, been forwarded to General Napier for his approval, and, should he desire it, the necessary materials will be sent out. The principle of Mr. Haddan's portable railway is to construct longitudinal sleepers or pontoons in the form of long sheet-iron cans, which, when used, are rammed with earth or sand to give them the necessary stability. The various pieces, rails included, do not weigh more than about 50 lb. each, and they are thus quite portable, and there are no loose bolts or other small pieces to get mislaid or lost. Each piece is made distinct in itself, the rail being rivetted down to the sleeper; so that one end projects while the reverse end recedes, and thus each piece breaks joint with its successor. Each tie-bar is provided with studs and turned-up ends, and has merely to be slid on to the ends of the last laid pair of rails, before the next pair are placed, and requires no bolts to keep it in position. The ordinary bridge rail fish-bar is used to obtain a junction longitudinally. Being air-tight, these land pontoons can also be used on water, and on an emergency they might be made to serve the purpose of gabions. A number of American tube-wells have been sent out with the expedition.

THE IRISH RAILWAY COMMISSION.—Mr. Price Williams, the inspecting engineer of the Irish Railway Commissioners, has instituted the most critical examination of every portion and detail of the railways in Ireland. The information collected is strictly confidential, and is to be laid before the Treasury, with the understood object of a Government purchase of the Irish lines.

FAIRLIE'S LOCOMOTIVE CARRIAGE.

A FEW weeks ago (*vide* pages 341 and 342 of the present volume) we called attention to a system of working on heavy inclines proposed by Mr. Robert F. Fairlie, and we also gave an engraving of a combined locomotive and carriage prepared from designs got out by Mr. Fairlie some years ago. At the same time we remarked that Mr. Fairlie had recently paid further attention to the matter, and that he had prepared some plans which were, in many respects, improvements upon the original ones. The two-page engraving which we give this week represents one of Mr. Fairlie's most recent designs. In our illustration, Fig. 1 is a side elevation; Fig. 2, a longitudinal section; Fig. 3, a sectional plan; Fig. 4, a front elevation; Fig. 5, a back elevation; Figs. 6 and 7 are transverse sections; and Fig. 8 is a plan showing the arrangement of the frame.

It will be seen by these views that the "locomotive carriage," as it may be termed, is carried on a pair of steam-bogies, each having six coupled wheels, these bogies being connected by a frame, constructed, as shown in the plan, Fig. 8. This frame, besides forming a rigid connexion between the two bogies, carries the boiler, tanks, and compartments for the passengers and goods; and the bogies themselves are simply connected with this frame by centre-pins, check-springs being, however, provided to ensure lateral steadiness. The boiler is of the ordinary locomotive pattern, and its barrel is surrounded by a compartment in which goods can be stowed. A section of this goods compartment is given on the left-hand side of Fig. 6. The firing is performed in the usual way, the stoker standing behind the firebox; but the driver is provided with a raised platform placed about level with the top of the firebox-casing. The driver, when standing on this platform, has a clear look-out ahead over the top of the goods compartments, the latter being kept lower than the passenger compartments in order to afford this clear view. Each bogie is provided with a pair of outside cylinders, and the steam is conducted to these cylinders through pipes arranged in the same manner as in Mr. Fairlie's other engines, previously described in this journal.

That portion of the vehicle devoted to passengers is, together with the greater part of the weight of the tanks, carried by the trailing bogie, and its arrangement will be readily understood by reference to the engravings. It will be seen that there are two stories, the lower story or compartment affording accommodation for forty-four first-class and the upper story for forty-eight second-class passengers. There are thus seats for ninety-two passengers in all. The lower compartment is entered by side doors, and the upper compartment by an end door, this door opening on a kind of gallery, to which access is obtained by steps, as shown in Fig. 6. The upper compartment has transverse and the lower compartment longitudinal seats, and it will be noticed that the water-tank is partly situated under the central seat in the latter compartment. The other constructive details will be readily understood from reference to the engravings.

The "locomotive carriage" illustrated is designed for the 4 ft. 8½ in. gauge, and its principal dimensions are as follows:

Diameter of cylinders	...	...	...	0 11½
Stroke	...	...	...	1 4
Number	...	...	...	4
Wheel-base of each bogie	...	...	...	6 6
Distance between centres of bogies	...	...	...	20 3
Diameter of wheels	...	...	...	2 6
" boiler-barrel	...	...	...	3 5
Length	...	...	...	11 0
" of firebox-casing at top	...	...	...	3 9
" " " bottom	...	...	...	4 0
Width of firebox casing at top	...	...	...	3 9
" " " bottom	...	...	...	4 0
Length of firegrate	...	...	...	3 5
Width	...	...	...	3 5
Width outside passenger and goods compartments	...	...	...	10 0
Cubic capacity of space for goods	...	...	...	620 cub. ft.
" " " passengers' luggage	...	...	...	87½ "
" " " coals	...	...	...	50 "
Contents of water-tanks	...	...	...	825 gals.

The total weight of the machine is estimated at 54 tons, of which about 29 tons would consist of carried load, divided approximately as follows:

Passengers	...	...	...	6½
Water	...	...	...	3½
Coals	...	...	...	1½
Passengers' luggage	...	...	...	2
Goods	...	...	...	16½

Total ... 29

Of this carried load, 24 tons would be paying freight, and the engine would be capable of drawing after it, even up an incline of 1 in 12, a further amount of paying load, as we shall show presently.

In the article to which we have already referred, we detailed very fully the principles upon which the system of working proposed by Mr. Fairlie is based; but it will be convenient that we should repeat some of the chief points here. In working heavy gradients, it is especially desirable to reduce the dead weight of the train to the lowest possible amount, every pound of dead weight being so much deducted from the quantity of paying freight which is capable of being hauled up an incline by a given amount of engine power. Now the engine itself is as much "dead weight" as the trucks or passenger-carriages, and it therefore, like them, should be made in the lightest manner possible, consistent with the provision of the requisite strength and boiler power. But, on the other hand, for working trains up heavy inclines a locomotive must possess a great amount of adhesion, and the question is how, with an engine actually light in itself, this requisite amount of adhesion can best be provided. Mr. Fell gets over the difficulty, after a fashion, by the adoption of the mid-rail and gripping-wheels; but his engines are, as we have recently pointed out in this journal, very complicated, and are

besides open to an immense number of practical objections. Besides this the raised mid-rail is itself objectionable in a line on which many level crossings occur; and although it has been stated that on the Mont Cenis line an ingenious arrangement has been provided for lowering the mid-rail at these crossings, yet we greatly doubt whether it will be found to be of any practical use. Mr. Fairlie, on the other hand, has taken what we may term a plain common-sense view of the question, and has altogether ignored the mid-rail or any other complex contrivance for increasing the adhesion of the locomotive. Instead of these, he simply proposes to place on the locomotive a sufficient proportion of the paying load to give the engine the required adhesion, the remainder of the load being dragged behind on separate vehicles in the usual way. In some cases it may be necessary to carry the whole load on the engine, but this will of course depend upon the gradients on which the engine has to be worked. In order also to give his engine the requisite flexibility, Mr. Fairlie arranges his engine in the manner which we have already described, this arrangement likewise enabling him to distribute the total load upon a large number of wheels.

The advantages of this plan over Mr. Fell's will be readily understood. In Mr. Fell's engine the pressure of the horizontal wheels upon the rails adds as much to the frictional resistances of the engine as if it was carried load, whereas it is of no use except for giving adhesion. In Mr. Fairlie's engine, on the contrary, the weight which gives adhesion is carried load, and the additional frictional resistance which is incurred in Mr. Fell's system by placing this load on trucks or carriages is saved. Another great advantage is the perfect flexibility of the arrangement. The engine which we illustrate this week, with its two bogies, each having a 6 ft. 6 in. wheel-base, would traverse with the utmost ease any curve which is likely to occur even on a mountain line. From the arrangement of the bogies and connecting-frame, also, this shortness of the wheel-base of the bogies in no way interferes with the steadiness of the engine, whereas in Mr. Fell's engines, notwithstanding that their wheel-base is longer, there is a great amount of objectionable overhang.

In comparing the two plans, there is another important point which deserves attention. In the case of the Mont Cenis line, the trains which it is intended to run are comparatively light, and the engines, consequently, are of but moderate power. In the case of many mountain lines which are likely to be constructed during the next few years, however, the circumstances will probably be very different. In order that these lines should pay, there will have to be a heavy traffic carried over them, and this will, of course, necessitate the employment of powerful engines. Now it is difficult to see how very powerful engines can be constructed on Mr. Fell's plans, unless a portion of their weight is carried on wheels which are not coupled up, and the adhesion of which is consequently not available. The Fell engine, if it is to work freely round curves, can scarcely have more than four coupled wheels, and if all the weight of a powerful engine was carried on these, the weight on each wheel would be excessive. Mr. Fairlie, on the contrary, has twelve wheels available on which to carry his load, and this number might even be increased to sixteen with making the wheel base much greater than that of the present Fell engines.

We must now say a few words about the capabilities of the engine shown in our engravings. The frictional resistances of such an engine should not certainly be more than 18 lb. per ton, and we therefore assume that resistance in our calculations. On an incline of 1 in 12, the resistance due to gravity would be 186.88 lb., or say 187 lb., per ton, making, with the frictional resistances of 18 lb. per ton, a total resistance of 205 lb. per ton. The total resistances of the machine on an incline of 1 in 12 would thus be

$$\begin{aligned} 54 \times 205 &= 11,070 \text{ lb.} \\ 11,070 &= 18,480 \text{ lb.} \end{aligned}$$

On an incline of 1 in 12, also, the weight available for adhesion would be reduced to $\frac{1}{12}$ of the total weight, or to 49½ tons, and, taking the adhesion at $\frac{1}{4}$ this weight, it would amount to

$$\frac{49\frac{1}{2} \times 2240}{6} = 18,480 \text{ lb.}$$

With steam at a pressure of 170 lb. per square inch in the boiler—and there is no reason why this pressure should not be safely carried—an effective pressure of 140 lb. per square inch on the pistons might be maintained throughout the stroke; and under these circumstances the two pairs of 11½ in. cylinders, with 6 in. stroke, would give a tractive force of

$$\frac{11.5^2 \times 10 \times 2 \times 140}{30} = 132.25 \times 16 \times 2 \times 140$$

$$\frac{30}{30} = 19,749.3 \text{ lb.,}$$

an amount slightly in excess of that which the adhesion (supposing this latter to be only $\frac{1}{4}$ of the insistent weight on the wheels) would be capable of taking up. If any objection is raised to the high pressure of steam above assumed, it might be readily met by lowering this pressure, and correspondingly increasing the size of the cylinders.

The resistances of the engine on an incline being 11,070 lb., and the tractive power (as measured by the assumed adhesion) being 18,480 lb., there would remain a tractive force of 18,480—11,070=7,410 lb. available for drawing a train behind the engine. Of the train thus drawn, the frictional resistances would probably not exceed 10 lb. per ton, which added to 187 lb. per ton, the resistance due to gravity on an incline of 1 in 12, would give the total train resistances 197 lb. per ton. Dividing 7,410 lb. by 197 lb., therefore, we get 37.6, or say 37 tons, as the load which the engine could draw behind it on the incline above mentioned. Of this 37 tons, 24 tons probably might be paying load, which added to the 24 tons of paying load carried on the engine itself makes the total amount of paying freight 48 tons.

Altogether Mr. Fairlie's system has strong points in its favour, which entitle it to the earnest attention of engineers constructing or having charge of lines abounding in steep gradients or sharp curves. In India it might with advantage be adopted for working cheaply constructed branch lines serving as feeders to the main trunk railways, and it might also be advantageously employed on such a line as it has been proposed to construct in Abyssinia. In the latter instance a line, capable of being worked on Mr. Fairlie's

system, might be constructed in the most rough and ready manner, the great flexibility given to the engine by the adoption of the double-bogie system enabling it to adapt itself readily to any inequalities in the road.

STEAM-CULTIVATION.

At a recent meeting of the East Lothian Farmers' Club, Mr. Shirriff, Saltcoats, drew the attention of the club to the subject of steam-cultivation, more especially with reference to the system of letting out his plough for work, introduced by Mr. Sadler, Ferrygate. Referring to the great changes which had taken place in agriculture within the last twenty years, Mr. Shirriff said there could be no doubt that its progress in future would be materially affected by the use of the steam-plough. In Scotland, agriculturists had been as yet slow to appreciate the benefits of the steam-plough, as was shown by the fact that while there were 400 of these implements at work in England, there were only ten in Scotland, seven of which were at work in East Lothian. The original outlay was doubtless very heavy; but the value of the cultivation on the land was almost incalculable. He gave some practical illustrations of the work done on his own farm (Saltcoats) by Mr. Sadler's plough. The first field had 17½ acres of light oat stubble, which the plough had stirred up to a depth of 16 in. in two days, at a cost of 10s., which a pair of horses would have taken thirty days to perform. Another field of potato land, 31½ acres in extent, had been ploughed in 1½ days, which would have taken sixteen days of a pair of horses. In one particular case, where the soil was as hard as adamant, and which no horses could have worked, the steam-plough had turned over to the depth of 14 in. in two days. There could be no question of the value of these results, and he believed the Club would join with him in wishing it every success.

Mr. Sadler, Ferrygate, followed up the observation of Mr. Shirriff by detailing his experience of the implement. After many difficulties he was now convinced of the success of the experiment which he had introduced into the county. He stated that he was engaged in an experiment at the instance of the Highland Society, and without anticipating the report which he would have to make to the directors, he might say that the result arrived at was four bushels of wheat per imperial acre in favour of the steam-plough as compared with ordinary cultivation. He knew that the use of the steam-plough, and the great facilities which it gave for rapid cultivation, would necessitate a change in the system of rotation, which was of no benefit to the proprietor, except with bad tenants. Improved cultivation meant higher rents, and in this aspect of the question it would be for the benefit of landlords to rid enterprising tenants of such old-standing bothers as the rotation system.

BESSEMER RAILS IN FRANCE.—We are able to state on private and excellent authority that the Terre Noire Company, whose works are near St. Etienne, France, have orders in hand for 30,000 tons of steel rails. The prices for the latter orders are 124.10s. per ton (or 310 francs per *tonne* of 2205 lb.), delivered at the works. The prices at other French works are 340 francs per *tonne*, or say 131.16s. per ton. At Terre Noire the melted pig is run directly from the blast furnaces into the converters.

AMERICAN RIFLES.—A friend and correspondent writes from New York to Mr. Colburn as follows: "I spent a few days with my old friend, Colonel Burton, at the Springfield Armoury. Burton has promised to send me drawings and description of his new ballistic chronoscope, an invention of his own, which is very simple. He says it will work as close to time as Schuttz's machine, which can indicate $\frac{1}{1000}$ th part of a second. Burton's can be made for about \$50; Schuttz's costs, I suppose, over \$1000. I will send the drawing to you when I get it. Burton is converting 50,000 of the Springfield rifled muskets into breech-loaders on Allan's arrangement, with improvements of his own. I was surprised to find him altering the barrel by boring it out and putting a steel lining in it, reducing the bore from 0.58 to 0.50, altering the twist from one turn in 6 ft. to one in 3 ft., reducing the depth of the grooves to a mere nothing, and, of course, having no increased depth of groove from muzzle to breech. This new breech-loader has already been used twice against the Indians on the plains, and with success and great effect. It is a splendid arm, and I doubt if any Government has any better. Captain Tyler, of the Royal Engineers, is here. I will try to get him to visit the Springfield Armoury. I hope to write you something of interest before long, but I am too cursedly lazy to do much."

BOILER EXPLOSIONS.—The number this year is likely to be less than for several years previously. Within the last few days, however, we have had the explosion of an agricultural engine boiler, killing two persons, and, again, the explosion of a boiler at Langley Mill, Nottingham, killing three persons.

FRENCH PROGRESS.—A loan for 28,000,000*l.* is about to be invited by the French Government for works of public utility, many of which will involve extensive engineering constructions.

THE RODMAN GUN.—*The Army and Navy Journal*, of New York, is crushingly hard, but not too hard, upon *The Engineer*, for its recent blunders and onology upon the subject of the Rodman gun and the Swedish monitors. Our American contemporary need, however, fire only reduced charges, as the visible bulk at which it aims is only a shell of printing paper, and is nowhere accepted as an authority in this country.

DUDGEON'S TUBE-EXPANDER.—We are glad to state that Mr. Dudgeon, the patentee of the best tube-expanding machine yet produced (and which we illustrated in *ENGINEERING* of October 12th, 1866), has come to England to push his valuable invention. His present address is 18, London-wall, E.C.

RUSSIAN RAILWAYS.—Mr. Morgan Williams, C.E., has left for Russia, to inspect the Nicolai (St. Petersburg and Moscow) Railway, with reference to its possible purchase by Messrs. Baring Brothers and Labouchere.

— — — — —