

TUNNELLING THE TEES.

MR. HEAD, of Middlesboro', in the course of a paper lately read by him before the Cleveland Institute of Engineers, upon a proposed railway under the Tees, to connect Middlesboro' with Norton Junction, and thus save six miles over the present route to the Bishop Auckland coal-fields, thus treated of the proposed river tunnel.

Referring first to a former scheme for a bridge, he said:

"When a plan like this was proposed, a couple of years ago, it met with violent opposition, on the ground that a bridge over the Tees would be injurious to the port of Stockton. It was said that the upward flow of the tide would be impeded, and the depth diminished. Further, it would prevent the downward passage of those large ships for the building of which Stockton has become so justly famous; and would thus affect the prosperity of the shipyards.

"The breadth of the river at the point of crossing is just 400 ft.; the distance from Middlesboro' Station to this part of the river is a mile, or 5280 ft.; and the level of the rails at the station is, say, 12 ft. above the highest spring tides. Now, 1 foot in 100 is a perfectly workable incline, and in the interval between the proposed tunnel and the Middlesboro' Station we should have a fall of 53 ft.

The height of the rails at the station above highest spring tides	12
Depth of the river at spring tides not more than	20
Interval between the bed of the river and the top of the tunnel	3
Thickness of the crown	3
Height of the tunnel	15
Total	53

The tunnel would be the lowest portion of the line, and the gradients at either side might be similar. The momentum gained by a descending train would, to a great extent, carry it up the opposite incline.

"We now come to consider the best method of constructing the tunnel. I propose that it should be a single wrought iron tube, but divided into two passages by a water-tight web, or bulkhead. This division should be strong enough to resist the pressure of the water, and preserve, at least, one side for traffic in case of accident to the other.

"As to the construction of the main tube, I would recommend something on the same principle as that exhibited in the hull of the Great Eastern steamship, i.e., an outer and inner shell, for security and strength. The bottom should be made flat, or slightly arched downwards. The whole section would thus resemble that of a gas-retort or culvert.

"The best plan for placing the tube in position seems to be as follows: As near as possible to the point of crossing it should be constructed by the river side, in a temporary dry dock formed by earthen embankments, and at such a level that the tide would float it, if admitted by the removal of a dam. The tube should be erected upon timber baulks placed crosswise at intervals of 5 ft., and bolted to the structure.

"These would be floated away with it, and afterwards serve as sleepers.

"Meantime, the groove in which it was intended to lie would be cut across the channel of the river by dredgers. It is no new thing to dredge to an increased depth of 30 ft. It is, in fact, the cheapest method of excavating in all cases where it can be applied. The new Suez Canal has been greatly indebted to the use of dredging in the formation of its approaches. Dredgers have even been made to cut their way into the solid shore, the water following to float them as they made a channel for it.

"In the bottom of the groove so prepared concrete must be tipped from barges, and spread to a level by the aid of diving-bells.

"When the tube was completed it would be necessary to cover over the ends temporarily to make it water-tight. It would then easily be floated out of the dock to its permanent position. To let in sufficient water to sink it would not occupy many minutes more. The interval between the ebb and flow, which at spring tides is about an hour, would be ample to accomplish everything necessary. Concrete might then be tamped at the sides and over the top, and in this way, assisted by the natural tendency to silt up, it would soon become permanently fixed. Embankments of clay would now be thrown out from the shore on each side of the line of the approaches, and would join across the end of the tube. As soon as they were made water-tight with clay puddle, the water between must be pumped out and the approaches built in the intervening space.

"In order to avoid the tunnel becoming a drain for the surrounding district, it would be necessary to cover in a certain distance of the approaches on either side. Such portions would be, in fact, brick tunnels. They would be lighted from the top by shafts at frequent intervals. The land above might be made available for standage, sidings, or other purposes. The tube with the covered portion of its approaches would form one continuous tunnel. If they were covered in for a distance of half a mile, their under side would have risen 26½ ft., or somewhere about the level of the outfall of the drainage of the neighbourhood.

"The only water which could then get into the tunnel would be that which might filter through the brickwork. This would run down to a well or sump-hole at one end of the tunnel, and a small steam pump would easily deliver it thence into the river.

"We now come to consider the question of cost. In the Britannia Tubular Bridge, each length of 400 ft. weighed 1200 tons. The length of our proposed tunnel is also 400 ft., but, inasmuch as it is designed for a double instead of a single line of rails, we will reckon it as being double the weight per foot of the above tubular bridge, which gives us 24,000 tons as the weight of the tube. This, at 15l. per ton delivered, is 36,000l. Suppose we allow 16,000l. for erection, and material and expenses connected therewith, we have 52,000l. as the cost of the tube when fixed in place. Let us

now estimate for the casing in of the approaches. If the brickwork were 27 in. or three bricks thick, and were carried under as well as above the tunnel, the sectional area would be about 38 square yards. Brickwork of this description would be, say, 10s. per cubic yard. At this rate, therefore, the casing would amount to 19l. per yard run, or 33,620l. for a mile. Adding this to the 52,000l. already obtained, we have 85,620l."

SMALL PUMPING-ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—Our own charity covers such a multitude of our own sins that I have long since cultivated that virtue, in a humble way, by omitting to read a certain contemporary of yours, lest I should think uncharitably of the paragon of engineering genius who evidently conducts it. An apprentice, however, who, but fourteen years of age, is perhaps less critical than older engineers, has shown me the following profound dictum in a leading article in *The Engineer* of Friday last:

"It is urged that this latter form of engine (the beam) is more costly than any other. If by this it is intended to convey that more money can be spent on this than on any other form of stationary engine, we shall not attempt to dispute the proposition; but we can assure our readers that it is quite possible to construct a beam-engine as cheaply as any other."

Indeed! And what must be thought of such an assurance? The beam-engine must necessarily contain all the parts of a horizontal engine, and numerous heavy parts in addition. Probably every mechanic who has worked upon steam-engines knows this. A striking case in point was instanced in the very paper under notice, July 24th, 1863. Messrs. Mirlees and Tait, of Glasgow, make, for a certain sized sugar-mill, a 22 in. cylinder non-condensing beam-engine, with a 4 ft. 6 in. stroke, or a horizontal engine having the same sized cylinder and 4 ft. stroke, according to order. Both engines, as designed by the same makers, for the same work, are proportioned for equal strength and stability. The beam-engine, however, weighs 44 tons 9 cwt., and the horizontal engine less than 20 tons! The difference of 6 in. in the stroke does not account for more than 6 or 8 tons, if, as much, in the weights; and it may therefore be said that the horizontal engine weighs less than two-thirds as much as the beam, and this difference of weight of course represents a considerable, although not a proportionate, difference in cost. I may tabulate these differences in weight as follows:

	Beam.	Horizontal.
	tons. cwt.	tons. cwt.
Bed-plate	7 14	4 13
Columns (six)	5 2	none.
Entablature	3 5	none.
Beam	2 5	none.
Fly-wheel	13 10	9 0
Cylinder and covers	2 10	1 13
Other parts	10 4	4 12
Total	44 10	19 18

Your readers will hardly need to be told that the difference in the weight of the fly-wheel and cylinder is not due to the difference of construction; but, allowing the same weights in both cases, we shall have, say, 44 tons in one case against, perhaps, 27 in the other.

The horizontal engine, taking the most advanced patterns, like Messrs. Galloway's or Mr. Ramsbottom's, is wholly self-contained. The beam engine, on the contrary, tends to lift its cylinder off the bed-plate by the full pressure of the steam (less the weight of the cylinder and the parts fixed to it) at each stroke, equal to a force of perhaps 10 tons in the beam engine named. This pressure is doubled at the main centre, and is again repeated at the journals of the main shaft. To resist these strains by its own transverse strength, the bed-plate would require to be enormously heavy. They are resisted, however, by other means, viz., by strong holding-down bolts, reaching deep into massive masonry, and the foundations of beam engines are necessarily costly.

It is true, as your astute contemporary observes, that the columns of the beam engine cost comparatively little; but the remaining extra parts, and the extra cost for foundations and for the loftier engine-house required, render the beam-engine nearly twice as costly as the horizontal engine of the same power.

I am, Sir, yours truly,

A JOURNEYMAN.

Manchester, December 3, 1867.

PROFESSIONAL FEES.—Professional gentlemen need not expect to be reasonably paid for any trouble they may take on the occasion of inquiries, if Professor Rogers's case may be taken as an index of what the authorities will do. On the inquest upon the death of Elizabeth Stainsby, who died in a train on the Metropolitan Railway, Professor Rogers was requested by the coroner to analyse and report upon the air of the tunnel. In the coroner's accounts, submitted to the committee of the Middlesex sessions, 10l. was charged by Dr. Lankester, on account of Professor Rogers, of the London University Hospital, for examinations and attendances on three occasions at the adjourned inquests held on Elizabeth Stainsby. Now, the committee, having taken the opinion of counsel some years ago, had no power to allow any sum not mentioned in the schedule of fees set down by Act of Parliament, and therefore they deducted from the charge on behalf of Professor Rogers the sum of 7l., leaving it 3l. only, and asked the court to sanction that disallowance. Mr. Kemshead mentioned incidentally that Dr. Lankester's accounts generally were high when compared with those of Mr. Humphreys, and that the coroner's charges cost the county annually a sum of not less than 12,000l., which was a very serious item in the county expenditure. He moved that the sum of 10l., included in Mr. Lankester's accounts for the services of Professor Rogers, Professor of Toxicology at London University Hospital, at the inquest held on the body of Elizabeth Stainsby, be not allowed. The motion was put and unanimously agreed to.

METROPOLITAN TRAMWAYS.

TO THE EDITOR OF ENGINEERING.

SIR,—It seems that the Metropolitan Tramway Company (Limited) are preparing our minds, what with placards, &c., posted all over the metropolis, and by their petition to Parliament, would claim a monopoly of our leading thoroughfares. Well, I wish them success in their endeavours, for undoubtedly we require a more rapid mode of transit through London. I have no objection to tramways so as to suit all conveyances, but I have a decided objection to a tramway having the wheels of the carriages flanged, and I think the generality of engineers are of the same opinion, and I may add, from our former experience in such a mode of transit in our crowded thoroughfares, that all, from the costermongers to the Hansom cab drivers, voted it a complete nuisance. If we are to have tramways, by all means let us, but not in the way proposed. A tramway must be so constructed that the vehicles can leave the metals and traverse the streets. What would we think of an engineer that would propose running our locomotive railway system through and across our streets? and is the speed that the cars were driven at five years ago calculated to reduce the amount of accidents that daily occur? The London cabdriver is certainly the nearest shaver that we know of. Indeed, it may be said that the machines are lubricated to pass one another; but not so—it is the facility they have in evading each other. If our streets were formed so that the vehicles moved to and fro in a straight line, then the flange wheels would probably suit, with careful driving. But how often is a cabman asked to drive at a great speed in a locality he is not well acquainted with? If he were to cross a line of tramway, and a car rushing past at the same time where he did not expect it, how could the car get out of the way? And do we not see such collisions daily with the present system?

Their programme includes some streets having cab ranks in the centre of the streets, and they propose to run the line in the centre of the street, and, I suppose, the cabmen to shunt to the side. Here is a monopoly—two-thirds of the street taken up with a railway and a cab rank, and costermonger Joe and the "élite" of the land must be contented with one-third share. Some will say, not so; carriages can proceed on the same line of rail. Yes, they may do so with the wheels in the groove, and the coster's narrow wheel may do so; but how are they to get out of the groove when once in? They are going to petition Parliament, are they? The flange rail at Westminster-bridge was rather near the "big house," but it had soon to be cropped of its fair proportions, and I trust their bill will meet the same fate, at least so far as the crowded thoroughfares of London is concerned.

Yours truly,

OBSERVER.

London, December 2, 1867.

ROUND THE WORLD.—M. Behm, a Prussian author, has contributed to Petermann's *Mittheilungen* a statistical account of the means of transport and locomotion existing in the world at the present time. Beginning with the circumnavigation of the world, the oldest company is the Peninsular and Oriental Steam Navigation Company. Its voyages are thus estimated:—To Bombay, twenty-three days from Southampton; to Ceylon and Point de Galle, twenty-six days. The Messageries Impériales steamers go to the same destination. In the Transatlantic routes, England, Germany, and France compete. The voyage from Southampton to New York is given at twelve days, and to Panama at nineteen. During 1865 the voyages from Liverpool to North and Central America numbered 308. In order to make a voyage round the world by existing steam routes, M. Behm says the shortest course would be: From Marseilles to Alexandria, Suez, Aden, Point de Galle, Melbourne, Sydney, and Wellington. Thus the traveller would find himself at the antipodes in fifty-five days. The bi-monthly steamers to Panama would carry him thither in twenty-eight days. From Colon to St. Thomas occupies five days; thence to Southampton fifteen, and thence to Marseilles forty-eight hours. Thus in 104 days, or 3½ months, we might make the tour of the world. The route, *via* Ceylon, Singapore, Hong Kong, Yokohama, and San Francisco is two days longer. M. Behm puts the cost of such a journey at 277l. 10s. The railways of the world are 80,600 miles long. Over one-third the total length is found in the United States, or about 30,000 miles; England has 13,072; Germany (Austria included), 13,000 miles; France, 8400; India, 3200; Italy, 3080; Spain, 2020; Russia, 2600; Canada, 1810; Belgium, 1500; Sweden, 950; Switzerland, 730; Holland, 650. It appears that the railways of Prussia have cost just about half as much per mile as those in England.

THE CUNARD CONTRACT.—At a time when the Peninsular and Oriental Company have obtained a subsidy practically double that which they have heretofore enjoyed, viz., 400,000l. per annum, and, in case of a certain probable event, 500,000l., where they have before had 230,000l., the Cunard Company have offered to renew their mail contract, which terminates on the 28th of the present month, for much less than their previous subsidy. Four other steamship companies have offered to carry the American mails, receiving therefor the sea postage; but no one of these would undertake to start their ships from England on Saturday, the favourite day for American correspondence, nor to call at Queenstown.

SHEATHING IRON SHIPS.—In answer to a question by Sir G. Stueley, as to whether the method of sheathing iron vessels with copper, invented by Captain Roux, and adopted in the French naval service, had been tested by the naval authorities in England, and with what success, Mr. Corry replied, in the House of Commons, that as far as the Admiralty had been informed the method invented by Captain Roux had not been applied to any iron vessel of war in the French navy. It had, however, been applied to a wooden corvette, and the principle was well known to our professional architects. In their opinion our system was greatly preferable to that of Captain Roux. He might add that the question of coppering iron vessels had been for some time under the consideration of the Admiralty.

THE SHIP OF THE FUTURE.

TO THE EDITOR OF ENGINEERING.

SIR,—There are very few intelligent people who believe that we have arrived at perfection in naval architecture, either as regards speed, safety, or economy. But there are a good many who think that we are very far behind the age, although our steamers, whether built on the Clyde, the Mersey, or the Thames, are the finest boats afloat. We desiderate something that will induce great numbers of people to travel long distances by sea, say across the Atlantic, for instance, or round the Cape. To effect this we must not copy the Cunard or the Inman steamers even, except as regards safety. The French and the German boats excel them in comfort; but every line afloat is extravagant in its management, and this has to be met by heavy drafts upon the purses of the travelling public. Few things make people feel more sore than the belief that they have been overcharged, and when to that is added wretched accommodation, the culmination of the trouble is at hand. A kicking, rolling, wet vessel is one of the most disagreeable arrangements in the world, and surely no one can deny the claims of some of the "crack" steamers now plying on the Atlantic to these unenviable qualities. I have travelled by them, and know what they are, and bad is the best.

Now, I consider that a vessel which will not require a rack in her tables in any weather, that will give comfortable state-rooms, with space enough to move about, that will have saloons of ample dimensions, that will, in fact, be something like an hotel, with almost as little liability to sea-sickness, that will be reasonably cheap, say *half* the present rates, that will be speedy enough to run from Liverpool to New York in six days, that will carry several hundreds of first and second class passengers with ease, that will only burn from 70 to 80 tons of coal a day, and carry 3000 tons of cargo, that will require fewer hands to work her; and that will be the strongest vessel on the ocean—I consider this the *ship of the future*, and I hope the future of her advent is not far off. I send you the pamphlet concerning such a vessel, from which you will perceive that Captain Henry Randall, a man of genius and foresight, well and favourably known in all parts of the globe, has patented the plan of such a ship, and in this pamphlet you will also find the opinions of the leading American engineers, shipbuilders, and captains respecting the practicability of his plans. Let me add that he will soon be in this city with his models, and will explain to parties who may feel an interest in the matter all that concerns it. He was the first man in the United States to burn coal instead of wood on board his boat, in spite of the opposition offered by people of position and influence. He is a thoroughly practical man who has studied his profession thoroughly, and has "forgotten more than most sailors ever knew."

I enclose my card, and in doing so beg that you will have the goodness to permit your valuable and influential paper to be the medium of bringing the *Randall* ship before the public in this country. The subject should be ventilated, at all events, and your able pen would be worthily employed in wiping away the cobwebs of prejudice, which in no country have so strong a hold, I am sorry to say, as in this glorious country of ours.

Believe me to remain,
Yours faithfully,
CAMPBELL ROSS.

London, December 5, 1867.

HOW TO DRAIN A WELL.

TO THE EDITOR OF ENGINEERING.

SIR,—So it seems the "E. U." will not give up his "idea" without another spasmodic kick in its defence. The chilly reception his first burst met with has apparently damped his spirits, since his second letter is not half so funny as his first; in fact, the admission that he did not say what he meant in that letter is quite affecting.

There are two or three points in his last, however, quite up to the average of those in his first; thus, he speaks of pumping being necessary some time "after the roofing in of the station." It appears, then, the "E. U." imagines that to keep the water from rising in a well we have only to invert the bucket, or stick up an umbrella over its mouth.

Again he denies the soft impeachment of "innocence," and enters his claim to be considered a "sly dog," by stating that he proposed stopping up all the meshes of the sieve, with the exception of the one in which the pipe was to be placed.

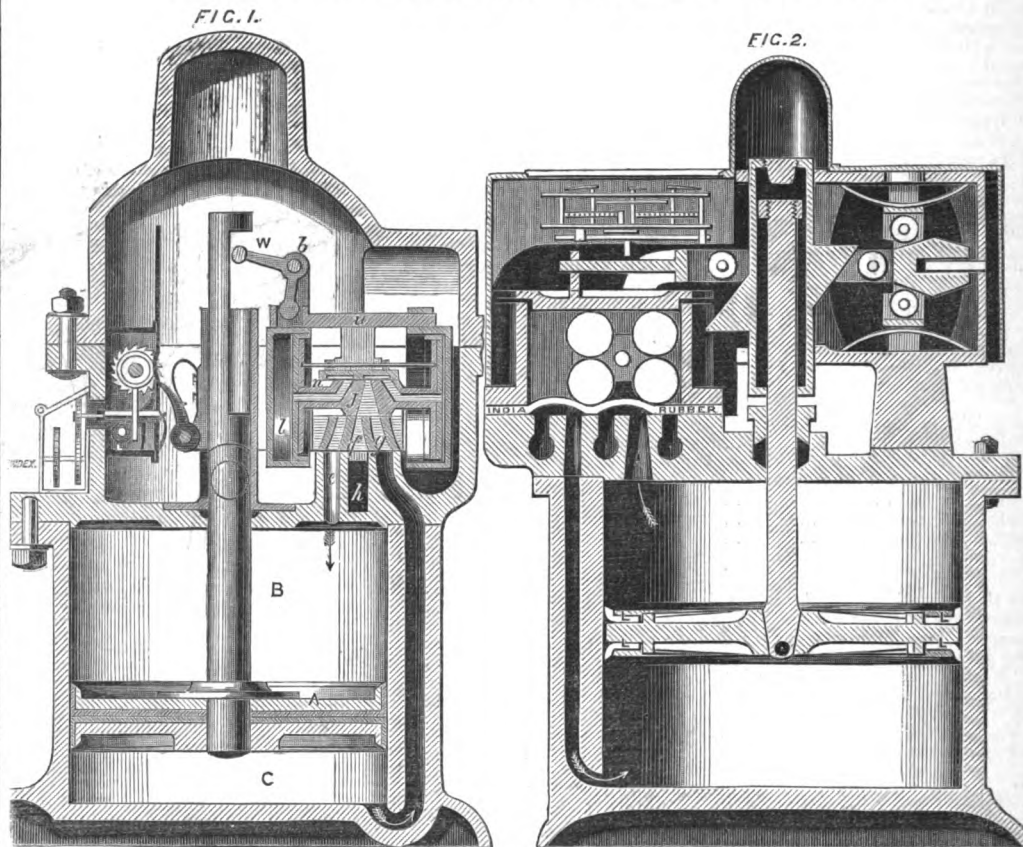
After the explanations in my last, this is satisfactory evidence that the "E. U." does not give the accepted interpretation to common English words. Possibly he may be of the nautical "persuasion;" if so, he may tell this to the marines: "If a vessel springs leaks in several places, let the water run into the bilge as usual, but don't pump; it is an obsolete and barbarous practice. All you have to do is to fix a pipe dipping into the bilge, and the water will 'swarm' up it immediately, and may be used for washing the main deck. On second thoughts, however, you may stop up all the leaks but one, and in that you may fix a pipe, when the water will run overboard as before."

Westminster. Yours obediently,
THOS. SQUARE.

P.S. The "E. U.'s" pun does not possess the same originality as his engineering. It is claimed, I am told, by my office-boy. Cheeky rascal!

VALUATIONS OF ROLLING STOCK.—The London, Chatham, and Dover Railway Company assigned its rolling stock, in January last, for the benefit of its general creditors, and agreed to pay a weekly rent for its use, at the annual rate of 6 per cent. upon its estimated value. The rent is now in arrear. The debenture holders, over whose claims this rent-charge takes precedence, have impeached the chief clerk's certificate of the value of the rolling stock, and are attempting to have it reduced *one-half*, which would reduce the rent in the same proportion, the amount of the reduction of rent then going to the debenture holders in part satisfaction of their claims.

RECIPROCATING WATER-METERS.



THE MANCHESTER WATER-METER COMPANY'S
METER. CERTAIN OF ACTION.

MYERS'S METER. NECESSARILY UNCERTAIN OF
ACTION.

On the occasion of the Great Exhibition of 1851, the jurors appointed to examine and decide upon the merits of the water-meters exhibited reported that none could be considered as trustworthy. In 1857, Messrs. Chadwick and Frost's meters, as now made by the Manchester Water-Meter Company, were patented, and these have since been very widely introduced, not only in Yorkshire and Lancashire, but also to some extent in the metropolis. In these, as in all properly constructed meters, the water is measured within a cylinder of known capacity, and its quantity recorded by the action of a reciprocating piston upon clock-work, registering, upon a series of dials, and like a gas-meter, to gallons, tens, hundreds, thousands, ten thousands, hundred thousands, and millions of gallons.

All water-meters, however well designed, and however good their workmanship may be, require some amount of pressure to work them. This pressure should be the least possible; and we may state, from our own knowledge, that some varieties of meters, such as Worthington's and its copy, Jopling's, may be made to register by merely blowing air into them from the mouth.

To work a meter with the least difference of pressure, it is requisite that the reciprocating piston shall not, of itself, work the admission and exhaust valves direct, but that it shall merely change the position of a smaller valve, which, once moved, shall effect with certainty the movement of the larger valve, and thus control the movement of the measuring piston. If it be attempted to maintain the reciprocations of the piston by causing it to directly open the regulating or controlling valve, the chances are many that the piston will stop after having moved the valve but halfway in its course; that is, after having shut off the admission of water under pressure from one side of the piston, without having opened the admission on the other side. In this respect a water-meter is under the same conditions as a steam-engine without a crank and fly-wheel. Many plans of steam-pumps have been contrived in which the piston-rod knocks over the steam valve at the end of each stroke; but no kind of steam-pumps are more uncertain of action than these. Water-meters in which the piston, in its reciprocation, knocks open the valve and reverses the motion, are even more uncertain, because the piston of a water-meter has neither the weight nor speed to give it the requisite momentum for continuing its course after the driving pressure is once off, as it must be for an instant while shifting the valve.

To overcome this difficulty, Chadwick and Frost, ten years ago, applied to the piston water-meter what had, even then, been occasionally proposed for

steam-pumps, and what Mr. Nasmyth had patented, twenty years ago, as applied to steam-hammers, viz., an intermediate piston-valve which, when acted upon by the main piston, should effect the movement of the main valve. This arrangement is not altogether suited to quick-going steam machinery, in which, as in a steam-hammer, the principal moving parts have enough momentum of their own to change the position of the steam-valve; but it is especially suited to the slowly moving pistons of water-meters, having neither the weight nor velocity requisite to shift the valves directly regulating their own motions.

The Manchester Water-Meter Company have for years followed the plan whereby the main measuring piston knocks open a little slide-valve admitting water under pressure to one of a pair of smaller pistons working the main valve, and water-meters thus made are certain in their action, and but a very slight "head" or pressure of the water is lost in passing through them.

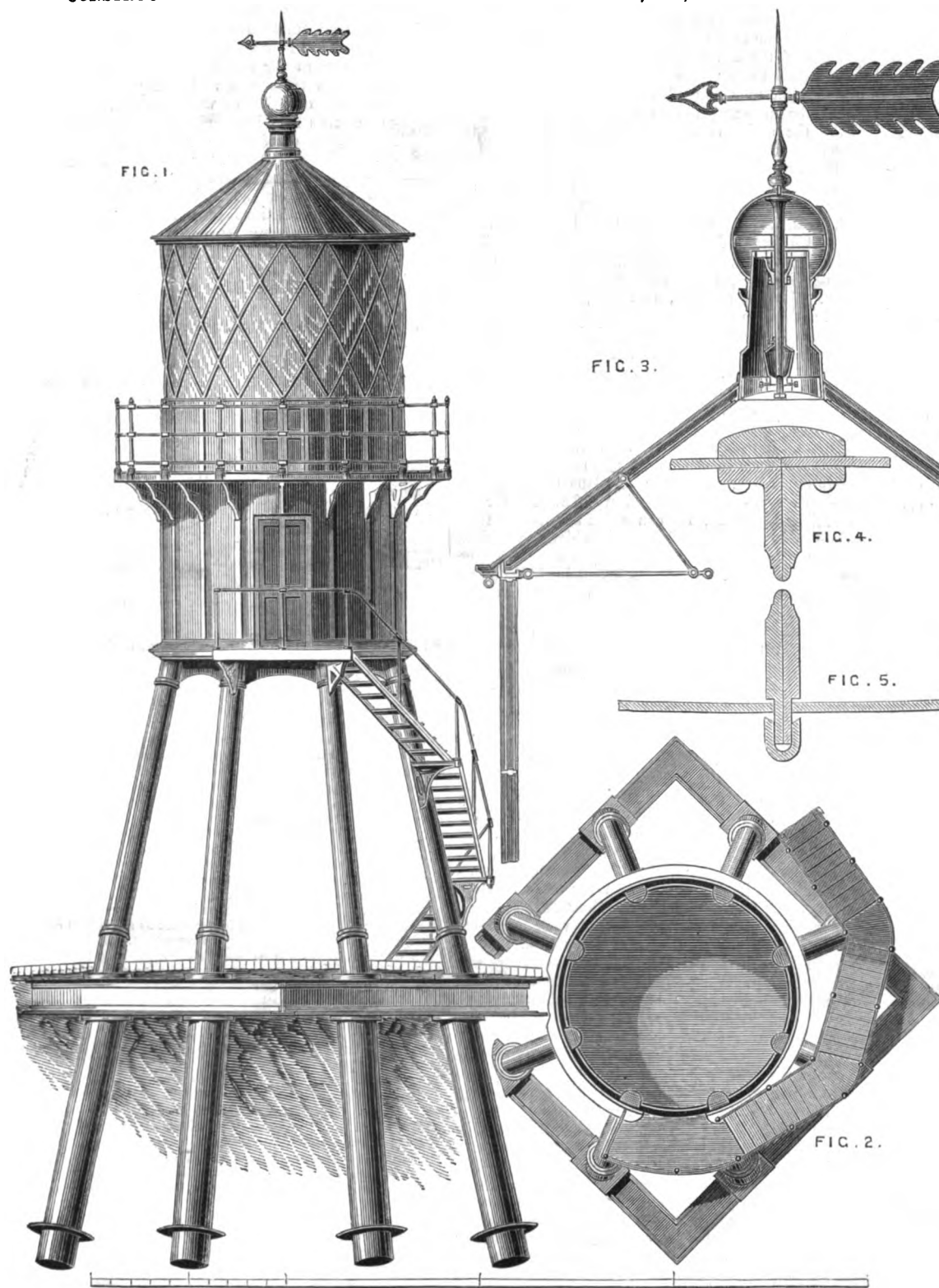
We last week received a prospectus of the "London and Westminster Water-Meter Company," claiming for their meters all the advantages of the Manchester Company's meter, viz., accuracy and certainty of registration, with a minimum loss of pressure. In the former affair, known as Myers's, the reciprocating piston knocks open the reversing valve at the end of each stroke. But we need not further explain to the practical engineer that, in doing this, with an ordinary valve, the latter might stick halfway, and the whole affair come to a standstill. So the old, *old* expedient is adopted of so arranging a pair of springs that, during the *first* half of the motion of the valve, they shall resist its movement, while during the last half they shall help it. We give below sketches of the respective apparatus, which will make their whole construction clear; but it needs no explanation to show that the "London and Westminster Water-Meter Company" cannot be depended upon for certainty of action. Not that their meter would not, when in perfect working order, measure accurately; but that, after a considerable period of use, it would not measure at all.

When we remember that there are dozens of piston-measuring water-meters, the following extract from Myers's prospectus reads impudently enough:

"The excellency of this instrument as a water-meter consists in its measuring the water by means of a chamber in which is placed a moveable division or piston fitted accurately to the interior of the cylinder; so that, instead of an inferential, there is an *actual* measurement of every quantity of water drawn through it, combined with the peculiar valve by which the supply of water is admitted first to one side and then to the other side of the piston, and also the lightness and compactness of the whole."

LOWESTOFT LOW LIGHTHOUSE.

CONSTRUCTED FROM THE DESIGNS OF MR. JAMES N. DOUGLASS, C.E., BY THE REGENT'S CANAL IRONWORKS COMPANY (LIMITED).



the flanges; these are 16 and 18 in. wide, and, as well as the webs, are made of $\frac{3}{4}$ in. plates; the angle-irons are 4 in. $\times$ 4 in. $\times$ $\frac{3}{4}$ in.; and the rivets $1\frac{1}{2}$ in. diameter. This frame, moreover, is rendered perfectly rigid by means of four diagonal braces, also made in the shape of single-webbed girders of the entire depth of the main girders between their flanges.

The superstructure, which consists principally of service-room and lantern, rests immediately upon eight wrought-iron piles 14 in. diameter, keyed at the foot into wrought-iron sockets provided with flanges, through which they are bolted to the foundation-frame by means of $1\frac{1}{2}$ in. bolts. The piles are 17 ft. 6 in. long, and stand at the same angle with the horizon as the bearing piles; they are connected at the top by eight wrought-iron girders bent to circular shape, and in such manner that when put together they form a short frustum of a cone; they are 1 ft. 8 in. deep at the ends, but slightly hollowed out so as to relieve the eye of the monotony of straight lines. The junction of the piles with these girders is made by means of $\frac{3}{4}$ in. plates bent round of and rivetted to the piles, and flanged out in such manner as to clip the ends of the webs of the girders which are rivetted to them; these webs are $\frac{3}{4}$ in. thick, and their bottom edge is thickened by means of half-round beading iron 3 in. wide; the top flange consists of a strong $4\frac{1}{2}$ in. angle iron, to which the floor-plates and the wall of the service-room are rivetted. This floor is carried by eight rolled joists, consisting each of two channel-irons 9 in. deep, rivetted together back to back, and framed so as to form a central ring 3 ft. in diameter; at the outer extremities they are bent round so as to clip the piles and abut against the main girders, to which they are rivetted as well as to the piles. The flooring consists of $\frac{3}{4}$ in. plates rivetted to the joists, and of $1\frac{1}{2}$ in. slate slabs bedded on to the plates with Portland cement.

The joints of the piles, main girders, floor joists, and wall plates are hidden by means of a neat cast-iron cornice.

The walls of the service-room, which is cylindrical, consist of sixteen rectangular bulb angle-iron frames about 12 ft. 3 in. high, welded solid at each corner; they are rivetted together in their vertical joints, and at the bottom they are rivetted to the angle iron of the main girders through the $\frac{1}{2}$ in. floor plate. Wrought-iron plating $\frac{1}{2}$ in. thick, bent to the diameter of the room, forms the outer skin of the wall, the plates being butt-jointed in the vertical seams which correspond with the joints of the frames, and covered with 6 in. strips. This plating is made in two lengths, the lower portion extending from the level of the floor-plate of the service-room to the level of the lantern floor, and the upper portion from the lower surface of the lantern gallery to the bottom cill of the lantern, each of the plates of this row being dished out so as to provide a 2 in. air-space between them and the lower row of plates, which it will be perceived they overlap to the extent of about 2 ft. These air-spaces are for the purpose of ventilating the lantern, and each of them is provided with a gun-metal hit-and-miss valve, having eight openings $4\frac{1}{2}$ in. long $\times$ $\frac{1}{2}$ in. wide; the valves are fitted into cast-iron panels well jointed together, so as to form an air-tight inner skin along the base of the lantern.

Access is had to the service-room by means of an outer staircase winding round the wrought-iron piles, to which it is fixed by means of cast-iron brackets. The stair stringers are of wrought bulb iron, and the steps, as well as the landings, of cast iron perforated with diamond-shaped openings; the hand-rail standards are of wrought iron, and the railings of hollow wrought-iron tubes $1\frac{1}{2}$ in. in diameter.

The door from the landing at the level of the service-floor opens into a small lobby or antechamber, from which another door opens into the service-room, by means of which arrangement this room is protected against the weather outside when any person either enters the room or leaves it.

The lantern floor is carried by eight joists similar in section to those of the lower floor, and framed in the same manner, provision being made of course for the stair-well; the joists are made to clip the frames of the wall of the room, and are rivetted to them. The flooring consists of slate slabs $1\frac{1}{2}$ in. thick, but a narrow portion about 2 ft. wide round the wall is covered with open gratings for the purpose of ventilating the service-room. The height from the service floor to the lantern floor is about 10 ft. 6 in.

A gallery is fixed to the outside of the service-room and all round it, at a level 2 ft. below that of the lantern floor; the flooring-plates of this gallery are of cast iron perforated like those of the stair-steps, and carried by cast-iron brackets bolted to the wall of the room; the railing standards are of cast iron keyed to these brackets, and the rails, three in number, are wrought-iron tubes similar to those of the hand-rails of the outer stairs. A staircase fixed to the inside of the service-room, and fitted with ornamental balusters and brass hand-rail, leads to the gallery and lantern floor, a landing being provided at the level of the gallery, where a small door gives egress upon it.

The bottom cill of the lantern is a wrought-iron ring $5\frac{1}{2}$ in. wide, and the lantern framing, which is constructed on the helical principle with a pitch of 64 ft., is made of steel sash-bars 4 in. deep; both the quadrilateral and the triangular frames are welded up solid and bent to the true curve of the lantern, each separately; they are then rivetted together by means of two rows of $\frac{1}{2}$ in. countersunk rivets about 4 in.

In the accompanying engravings we illustrate the iron lighthouse recently erected at Lowestoft Ness Point.

The harbour of Lowestoft has for a considerable time been gaining in importance, and though we have no official information of the fact, we were told some years ago, during a short stay in those parts, that it was actually gaining the pace upon the ancient seaport of Yarmouth, on the ground chiefly that the approaches to the harbour are less difficult.

Two lighthouses have for a many years been standing there, for in 1831 we find there was a high lighthouse, apparently a permanent structure, at about the north-west corner of the town of Lowestoft, where it still remains, and a low lighthouse, at about the south-east corner of the town, the relative position of these two lights being such as to enable commanders of vessels to take their bearings when running up the then principal channel leading into the harbour. This low light was a mere wooden structure admitting of easy removal, and the channel having subsequently shifted, it was in consequence removed a little further to the south-east, and stood in this position in 1860, at about which period the channel in question closed up and the light became useless. In the mean time it was discovered that about the same period Lowestoft Ness Point had shifted considerably to the south, in conformity with the general direction of movement of the foreshore along this coast, as has been very elaborately illustrated and described by Mr.

Redman in a paper read before the Institution of Civil Engineers some three years ago.

This and other causes rendered a second light necessary, notwithstanding the closing up of the channel, and about the year 1864 the authorities of Trinity House decided upon erecting at the south-eastern extremity of Lowestoft Ness Point, the new iron lighthouse which we are about to describe.

By way of accounting at once for certain peculiarities of construction, we may state that Mr. Douglass, the engineer to the Trinity Board, in consequence of the known tendency of this foreshore to move steadily in a fixed direction, so arranged his design that the structure might be easily removed whenever found necessary; to this effect, namely, he made the superstructure totally independent of the bearing piles and foundation frame.

The bearing piles, eight in number, are of cast iron, 12 ft. 6 in. long and 18 in. diameter, placed into the ground at a batter of very nearly 1 in 4, their bearing blades being 8 ft. 6 in. diameter, and bedded into concrete; at their upper extremities the piles are provided with flanges to which the foundation frame is bolted. This frame, which is buried in a bed of concrete, is square in plan, and consists of four wrought-iron girders, 1 ft. 9 in. deep, rivetted together at their ends through the web-plates, which are bent in such a manner as to form a mitre joint, and also by means of covering strips over the mitres of

pitch; a gun-metal capping is screwed to the outside of the frames for the purpose of securing the glass, which is $\frac{1}{2}$ in. thick, and bent to the diameter of the lantern.

The topcill consists of an angle-iron about $5\frac{1}{2}$ in. $\times$ $4\frac{1}{2}$ in. $\times$ $\frac{1}{2}$ in., thickened in its vertical flange by a plate of the same thickness which is rivetted to it; the meeting faces of the cills and of the lantern framing are truly planed, and the framing is rivetted to the cills by means of two rows of $\frac{1}{2}$ in. countersunk rivets.

The roof is formed of sixteen braced frames, the rafters being made of rolled angle steel rivetted together back to back, and provided with mouldings to match those of the lantern framing; at the foot they are rivetted to the top cill of the lantern, and bolted at the crown to the ventilator-shaft. The roof is covered in with $\frac{1}{2}$ in. wrought-iron plates, butt jointed over the rafters, and covered with rounded strips. A cast-iron gutter, forming cornice, is fitted round the roof, and to the underside of this a wrought-iron rod is fixed by means of eye-bolts, for the purpose of leaning a ladder against when the lantern is cleaned, and for hanging curtains to.

The ball is made of $\frac{1}{2}$ in. copper, provided with a gun-metal ring at the bottom to fit over the ventilating-shaft, and stiffened in the centre by a gun-metal ring having four arms and a boss, through which it is keyed to the spindle. A number of holes are drilled into it on the feather side of the vane for the purpose of ventilation: these are covered by a copper plate fixed concentric to the ball at a distance of 2 in., to prevent the rain from driving in.

The spindle is made of steel hardened at the foot, and working upon an adjustable steel pivot screwed into a brass bush, which is fitted into the central boss of a cross bearer rivetted to the ventilator-shaft; this bush is prolonged to serve as an oil-cup, and is provided with a lid fixed to the spindle with a thumb-screw. At the top of the ventilator-shaft the spindle passes through another cross bearer fitted with brass bush, and an oil-cup is there screwed to the spindle in such a manner as to answer the purpose of a washer, to prevent the ball and spindle from being lifted out.

The vane and shaft are made of gun-metal, rivetted to the ball through a flange provided at the bottom of the shaft; but the feather of the vane is made of two copper plates, brazed together and screwed to the gun-metal rod of the vane.

The height from the level of high-water spring tides to the centre of the lantern is 40 ft., and the illuminating apparatus is a second-order dioptric light manufactured by Messrs. Chance Brothers, of Birmingham.

In our illustrations, Fig. 1 is a general elevation; Fig. 2, a sectional plan below the level of the service floor; Fig. 3, an enlarged section through the lantern and ventilating shaft, showing also sections of lantern-frames and rafters; Fig. 4, a section showing the connexion of roof joists and wrought-iron covering plates; and Fig. 5, a section through one of the sash bars.

The service-room is provided with all requisite fittings, namely, dwarf closet, slate shelves, table, Windsor arm-chairs, and stove, rain-water tank, oil-tank, and sink. Green moreen curtains are also provided for the windows, and brown curtains for the lantern.

The whole of the design was furnished by the engineer to the Trinity Board, Mr. James N. Douglass, and the work was executed by the Regent's Canal Ironworks Company, under the management of Mr. H. Grissell, whose great experience in cast-iron lighthouses of the ordinary tower-like construction, we have no doubt, has been greatly enriched by carrying out so novel a structure as this, made entirely of wrought iron, steel, and brass.

RUSSIAN RAILWAYS.

SINCE 1862, 113,000,000 roubles, or 17,000,000*l.*, have been avowedly expended by the Russian Government in the construction of railways. Of these 51,500,000 roubles were disbursed in subventioning private companies, 4,000,000 in purchasing shares, 1,875,000 in advancing funds, 54,750,000 in State railways, and the rest in improving and enlarging the harbour of Odessa. Of the lines building or built, six belong to Government and twenty-one to private companies, but the latter, with the exception of the Riga-Mitau line, are all assisted by public subventions or guarantees of interest, many by both. One cannot take up a Russian paper without finding intelligence about several new lines, one approaching completion, another just commenced, and a third projected and measured out. To the latter category just now belongs the so-called Siberian Railway, which is to issue from Sarapul, north-east of Kassan, and, crossing the Ural, proceed to Tumen, south-west of Tobolsk. It has the twofold object of connecting the Ural iron foundries with the neighbouring coal mines, and to form an entrance into the outlying provinces of Siberia. By the by, the Odessa and Novo-Selica Railway, has been lately called an "unimportant" one. Far from being so, it is both commercially and strategically one of the most useful yet contemplated. By linking Odessa with the Galician lines it will be the nearest road from Central and Western Europe to the Black Sea; by flanking the Moldavian frontier it will, to a certain extent, neutralise the future Jassy-Czernovitz line, which we remember having seen called in the *Moscow Gazette* a movable battery placed on the Russian border.

THE SOUTH-EASTERN AND BRIGHTON RAILWAY FEDERATION.—The most important further step that could at present be hoped for in the work of railway federation has just been arranged, the boards of the South-Eastern and Brighton companies having come to an agreement with the board of the London, Chatham, and Dover Company that will bring the working of the three lines into one harmonious system. The new plan is of course free from any involvement of the financial concerns of the respective companies, and provision is made for the difficulty of ascertaining, in the present undeveloped state of the Chatham and Dover line, the precise proportion of the earnings to which it may be entitled, by a condition that the question shall at the proper time be definitively adjusted through an arbitration with Sir William Erle, Mr. Gladstone, or Sir George Grey as umpire.

THE WATERWORKS OF LONDON.

MESSRS. SPON, of Charing-cross, have republished in an octavo volume, the series of articles descriptive of the waterworks of the metropolis, which appeared in *ENGINEERING* in the summer and autumn of 1866. These form the only connected account which has yet appeared of the works of the eight companies upon which nearly three and a half million people in and near London now depend for their supply of water. If there be any exception to this remark, it must be that of the series of articles which appeared, at the same time, in a contemporary, in which the works of the East London Company were first stated to exist at Shadwell, and afterwards at Chadwell, those of the Southwark and Vauxhall Company in the Belvedere-road, Lambeth, and those of the Grand Junction Company at Chelsea! Had the localities been given as Tany-bwlch, in Wales, Tooley-street, Borough, and Great Snoring, Norfolk, they would have been equally accurate. Such an account, therefore, was both *no* account, and *or* no account.

With the exception of the extended notices in "*The Waterworks of London*" of the New River and East London Companies, the series was prepared with the readiest, kindest, and fullest possible co-operation of the engineers of the various companies. The working drawings of Messrs. Harvey's great Cornish engines, of Messrs. Simpson's rotative engines, and of various other types, were loaned to us and retained for some time in our office, as were also plans of reservoirs, filter-beds, sand-washing machinery, &c. As for the New River Company, no connected account of their works—and they present but little which the modern engineer need wish to copy—had yet appeared, the engineers, since Mr. Mylne's death, refusing information alike to all who applied for it. Yet much information was available, notwithstanding. There was abundant evidence which had been forced from the company's engineers in the course of parliamentary inquiries, which only needed looking up. This evidence included the sources, extent, and quality of their supply, and the total quantity delivered to consumers, and at what rate per head, and over what area, and with what pecuniary results. Incidentally it included many facts as to their engineering works, their pipeage, and details of filtering and distribution. The late Mr. Mylne's admirable topographical and contour map furnished accurately all the levels, above Trinity high-water mark, of the company's many storage and subsiding reservoirs. As for the engines at the various pumping-stations, Mr. Colburn had visited most of them, years before, and gathered very full particulars of their working without, at that time, any view to publication. Besides, these engines had been described in various papers read before the Mechanical Engineers, and in Mr. Bourne's *Treatise on the Steam-Engine*, and there was abundant information available as to their working. Few cases could be instanced where, with so little to describe, and with such resolute trades-union prejudice in withholding information, all that was *worth* describing was, nevertheless, described. And the waterworks engineer may take our word that, with the exception of Simpson's engines at Stoke Newington, the New River Company have no plant worthy a moment's attention. The engines made for them by James Watt and Company (Heaven deny any connexion between them and the great founder of that firm!) were wretched failures, faulty in nearly every respect, and had to be well-nigh reconstructed before they could be depended upon to work at all. From various sources, and with much care in the way of personal inquiry, comparison, and reference, all that need be said of the New River Company's works has been said in the book under notice.

The East London Company's engineer, when applied to, in the summer of 1866, for information respecting his works, was busy in pumping unfiltered water, percolating from the river Lea, over the district supplied from Old Ford—a district within which 5500 persons died of cholera within a few months, last year. Under the pressure of such urgent duties it was not to be expected that Mr. Greaves could descend to any particulars as to his works; yet these were, nevertheless, sufficiently obtained from various authentic sources, supplemented by Mr. Colburn's own knowledge of the Old Ford and Lea Bridge works, as derived from previous visits. So far as they go, the accounts of the New River and East London works are as complete and authentic as any in the new book, "*The Waterworks of London*," albeit that the engineers of these works purposely withheld all information. And so far as their pumping-engines, filter-beds, &c., are concerned, these are described in abundant detail, from even better examples from other

works, whose engineers, instead of exhibiting discourtesy and jealousy, met the authors with every reasonable confidence and kindness.

In addition to detailed accounts of the works of the eight metropolitan water companies, the book under notice contains full particulars of Mr. Bateman's, Messrs. Hemans and Hassard's, and Mr. Remington's respective schemes for supplying London with water from Wales, Westmoreland, and Derbyshire; articles on the general question of water supply, the water supply of Paris (from information kindly supplied by M. Belgrand, the chief engineer of the works for the supply of Paris with water), the large and remarkable pumping-engines at Brooklyn and Cincinnati, U.S., the great turbines at the Philadelphia (Fairmount) Waterworks; descriptions in detail of the Dublin, Bombay, Aberdeen, and Altona waterworks, of the great lake tunnel at Chicago, the Washington Aqueduct, Marseilles Waterworks, and the Crossness pumping-station of the Metropolitan Main Drainage Works.

We may, even here, tender our renewed thanks to Mr. James Simpson, engineer of the Lambeth and the Chelsea Waterworks; Mr. Hack, of the West Middlesex Company; Mr. Quick, of the Southwark and Vauxhall and the Grand Junction companies; Mr. Morris, of the Kent Waterworks Company; M. Belgrand, engineer of the waterworks of Paris; Mr. Craven, of the Croton Aqueduct, New York; Mr. Kirkwood, of the Brooklyn Waterworks; Mr. Chesbrough, of the Chicago Waterworks; Mr. Birkenbine, of the Philadelphia Waterworks; General Meigs, of the Washington Aqueduct; Mr. Bazalgette, of the Metropolitan Main Drainage; Messrs. Simpson and Co., Mr. David Thomson, Mr. Froude, and others.

BURGH, MALLET AND CO.

TO THE EDITOR OF *ENGINEERING*.

SIR,—The *Practical Mechanic's Journal*, was, at one time, reputed to be a sound and useful journal. But this conviction its present editor seems likely to shake. It is understood that this erratic authority is none other than Mr. Robert Mallet, one of the great lights of your elderly contemporary, *The Engineer*, and this may in some measure account for the preposterous praise which he has bestowed upon Mr. Burgh's absurd book on "*Marine Engineering*," which you lately criticised, Mr. Burgh, it appears, being another member of the same sage fraternity that presides over the destinies of *The Engineer*, and a fitting measure of its capacity. "Claw me, and I'll claw you," seems to be the rule of this melancholy clique. But there is one circumstance likely to interfere with the success of their policy. Engineers, as a general rule, are able to judge for themselves on the topics submitted to their consideration; and when they see pure Balaam lauded as wisdom, the result will be not to overturn their natural and inevitable convictions that nonsense is, after all, only nonsense, but to suggest the doubt that Mr. Mallet as a judge is either unwarrantably partial or utterly incompetent. Mr. Mallet's criticism is recognisable as his, being signed by the editor, and thus having the responsibility resulting from his praise. But if we applaud his courage, it must be at the expense of his reputation for discretion, as a man capable of praising Burgh's book can only be conceived of as either unscrupulous or ignorant. It is true he takes some exceptions to about thirty pages of the text. But these thirty pages are no worse than all the other pages of it. The quality is homogeneous throughout. I do not suppose Mr. Mallet holds that Mr. Burgh was drunk or mazed when he wrote those thirty pages. Yet on any other hypothesis it is inconceivable that these thirty pages could be so bad and all the others so excellent. I do not know that Mr. Mallet is esteemed so infallible an authority, or is recognised as so sound, cautious, or practical a judge in engineering questions as to warrant him to presume, upon the imputation of these qualities, that it is safe to give the rein to his impulses, and to press upon others doctrines that are in themselves absurd. That he is possessed of talent I do not deny. But it is of the dilettante order, a mere *ignis fatuus*, more likely to lead himself and others astray than to impart any useful light. The praise which he has bestowed upon Burgh's book is evidence of the eccentricities into which he may be led. As you stated, the only thing not enormously faulty about the book is the drawings, which any draughtsman could furnish, and which are not Mr. Burgh's productions at all. It would be as relevant to praise the type as evidence of Mr. Burgh's abilities. Yet on this slender ground Mr. Mallet characterises Mr. Burgh's bundle of rubbish as "a capital book, the best, we are almost disposed to say, in existence in England at the present moment upon that highly important branch of engine-making, viz., marine engineering." Such is the gospel according to Mallet. But Mallet's sometimes have wooden heads,

I am, &c.,
AN ENGINEER.

Westminster, Dec. 3, 1867.

THE NEW RAILWAY OVER THE ALPS BY THE BRENNER PASS.—The railway over the Brenner seems acquiring popularity as a means of transit from Western Europe to Italy. Recent travellers speak in high terms of the convenience of the route, although it is a long stretch of rail—nearly sixty hours from Paris to Florence. It will hardly stand the opposition of the Mont Cenis line when once the summit railway shall have been opened, and the public mind satisfied as to its safety. But when is that to be, and what is Mr. Fell about?

THE SMITHFIELD CLUB SHOW.

DURING the last few months the agricultural engineers have been busier than usual, many of them having had all they could do. The improvement has been chiefly in the foreign trade, and is, no doubt, traceable to the maintained and rising price of wheat, which now averages 68s. a quarter, against 61s. at the same time last year, 46s. in 1865, and 38s. in December, 1864. France takes but little of our agricultural machinery, her import duty of about 10 per cent. upon it sufficing for the "protection" of her own engineers and implement-makers; but Germany and Austria are liberal buyers. Indeed France, with her subdivided farms, so often liable to further subdivision, when the *cultivateur* happens to leave two or more sons behind him at his death, is never likely to employ agricultural machinery largely, unless upon the "letting out" system. But in Austria and Hungary there are vast estates, and machinery is imported freely. One proprietor, to whom one of our large firms sold six portable engines not long since, has three estates of a total area of 50,000 acres. Indeed, Messrs. Clayton, Shuttleworth and Co. have found it necessary to fit up large branch establishments in Vienna and Pesth, and we believe that no less than 200 hands are employed at the Vienna works, a smaller number being employed, wholly on repairs, at Pesth.

The French Exhibition has probably also increased the foreign trade. We need hardly say that in the award of prizes to agricultural machinery and implements exhibited both in the Champ de Mars and at Billancourt, the English exhibits were almost invariably placed above all others. Besides this, the report of the committees of the Royal Agricultural Society upon steam-cultivation has greatly stimulated the purchase of steam-plough tackle both in England and abroad. The Steam Plough Works, at Leeds, and Messrs. Howards, of Bedford, have been particularly busy with this class of work, and we have reason to know that several sets have been sold also at the Smithfield Club meeting. Mr. Algernon Clarke, who was secretary to the principal committee, read a paper, on Monday evening, before the Farmers' Club, upon the subject of steam tillage, and we believe that something was said of "doing" 100 acres a day with a single set of tackle. We really do not know what may yet be done. Messrs. Fowler's eight-furrow balance plough, taking a breadth of 6 ft., and their new cultivator, first exhibited last summer at Bury, and which "takes" from 12 ft. to 15 ft., are doing wonders on light land. If they can be driven at the rate of four miles an hour, as it appears likely they yet may be, the eight-furrow plough would get through nearly 3 acres an hour, and the 15 ft. cultivator 7½ acres, or 90 acres in twelve hours!

The reports of the three committees were published in the Society's *Journal*, and were accessible to non-members only by the payment of 6s. Messrs. Howards have, however, republished all relating to the use of their tackle—and it is a great deal—in a new edition of their catalogue, and for gratuitous distribution.

Even the Bury show has helped, no doubt, to improve the portable-engine trade. It was the first show of the Royal Agricultural Society since 1865, and the first since 1863 in which steam-engines were tested and reported upon, if indeed, beyond the award of the prizes, it can be considered that the judges have made any real report, none having appeared in the Society's *Journal*. We, however, gave the results of these trials with a minuteness and accuracy never before attempted on the occasion of like trials, and an extra edition of 5000 copies of *ENGINEERING* was sent to the members of the Society, so that the real results were made widely and usefully known. A greater economy of fuel was attained at the Bury trials than had ever before been reported of portable engines, whether of the "racing" or ordinary commercial class.

The portable-engine makers began, this year, to experience the full effect of the reduction of about 9 per cent. in the prices of engines, so boldly made in June, 1866, by the leading house in the trade, and which carried so much consternation to more than a score of other establishments all over the kingdom, many of the proprietors of which, although since very busy, did not then believe, or at least admit, that it was possible to make engines at the new prices with any profit whatever.

Whatever may be the cause for an increase in the number of portable engines made and sold, it is one upon which both makers and farmers may be congratulated.

The Smithfield Club, as our readers know, offers no

prizes to implements, and, with the exception of gas-engines, water-meters, and occasionally one or two other kinds of apparatus, no machinery is exhibited in motion. The entries are so numerous, however, that even the large disposable space in the Agricultural Hall is very much crowded with machinery and implements, and anything like real examination is generally difficult. As for novelties, few were to be met with, yet something may be gathered from comparison.

The portable engines and the ploughing and traction engines formed, of course, the more important exhibits of machinery, and most of the leading makers were pretty fully represented, not, however, by the racing engines which gained such extraordinarily good results at Bury, but by examples of every-day work. On that occasion a number of engines were worked both at their nominal power and at one-half more than their nominal power. In the former class, a double-cylinder engine by Messrs. Clayton, Shuttleworth and Co., rated by them as of 12 horse power, and by the Society's engineers as 15½, worked for nearly 4½ hours' "mechanical time" with a consumption of 2.97 lb. of coal per effective horse power per hour. Ransomes and Sims's engine came next. Of the ordinary "commercial engines" tried, Messrs. Brown and May's engines undoubtedly attained the best results. When, however, the engines were tried to one-half more than their nominal power, a single-cylinder, 10-horse, long-stroke (18 in.) engine, by the Reading Ironworks Company, attained the best result of all, working with but 2.54 lb. of coal per indicated horse power per hour, although on the first series of trials, working only to the nominal power, it consumed 4.42 lb.

So far as the relative merits of different makes of engines is concerned, it may be said that of those tried at Bury the consumption of coal varied from 2.97 lb. to 12.92 lb. per horse power per hour, and the records of these trials, as contained in our pages of July 19th last, must be consulted in pronouncing any opinion upon engines by the same makers, and exhibited at the Cattle Show.

The consumption of fuel of a new engine is but an imperfect indication of its real value to the purchaser. We say a new engine, because if it is of inferior construction it will generally consume more fuel after a time than at first, and of course all the engines tried at the Royal Society's shows are spick and span from the makers' factories, with tubes clear from soot, and with no scale on them nor on the firebox, the pistons just tight enough, and everything in the best order.

The wearing qualities of an engine cannot be judged very fully from a mere external examination, nor always from the reputation of the makers, since the fact that one firm sells more engines than any other does not necessarily prove that theirs are the very best, but possibly that with superior manufacturing facilities they can work cheaper, and thus devote larger sums to those always heavy trade expenses by which only a manufacturer can rapidly push a new trade, or extend an old one, however good his wares may be. What but wonderful division of labour, the very best organisation and system, and the best mechanical appliances could have raised a small business, begun by two poor men twenty years ago, into one of the finest now known in English mechanical engineering, a business which is understood to have enabled one of its partners to bid 152,000*l.* for Newstead Abbey, the early home of Lord Byron? Again, engines are oftentimes purchased wherever they may be had of the desired size and construction ready made. Only one or two firms enjoy the advantages of such a capital as can enable them to keep on hand a stock of engines of various sizes and constructions. Every portable-engine maker is called upon to make engines of from 3 or 4 horse power, or even less, to 12 horse power, and we now and then see some of 20 horse power. Then there are the single-cylinder and double-cylinder engines, with and without expansion valves; engines with large fireboxes for wood, and others with smaller fireboxes for coal; engines with the cylinders in the smokebox, and others with them on the firebox; engines for ordinary barnyard work, and others of extra strength for steam-ploughing, contractors' use, &c. Few would believe that one single firm actually make about eighty varieties of portable engines, and that they find it necessary to keep a stock of at least one hundred and twenty on hand to meet orders for engines immediately wanted.

Messrs. Clayton, Shuttleworth and Co.'s engine is the acknowledged model of most other makers. It is admirably made of first-class materials, and with the help of the best machinery. Yet it does not follow that many imitations are not as good as the original. Just as no maker has a monopoly of good design, so no one now has a monopoly of good

materials or good workmanship. The results of the Bury trial do not settle the relative merits of the various makers, since those which attained the best results were of a special class, rarely made and seldom asked for in the trade. Besides, too, it would be found that another series of trials would, from the difference of circumstances always attending such trials, alter the relative position of many of the engines. Much, indeed, depended upon jockeying and firing, and here the engine-drivers necessarily differ more or less in knowledge, quick mechanical wit, and in manual skill. One of the best makers, Messrs. Marshall, Sons, and Co., took a place below their real merits from the circumstance that the blast nozzle of their engine, having been improperly fastened on, blew off at the beginning of the trial, and the steam-jet, of live steam, had to be turned on, at a considerable waste of fuel, to maintain the draught. These makers (Messrs. Marshall) had an eight-horse engine at Islington which was particularly well finished, and the design was that now recognised by all engineers as the first class in such work. The guide bars, we may note, were of steel, with the oil-cups worked out of the solid. The boiler was of a strength intended for working with 100 lb. steam for ploughing. The engineer would recognise many little neatnesses in the *toilette* of this engine, such as the handle on the firebox for putting on the blower or steam-jet by opening a cock in a pipe inside the boiler. This is not entirely new, but it is unusual, and is neat. A vertical engine and boiler for fixed machinery was a very good job. The cylinder bolted to the upper part of the boiler, and the shaft carried in brackets on a strong wrought-iron saddle below. The oil-boxes on the guide bars were made in the solid with the bars, and, so as to oil the four wearing surfaces more completely and economically than is always the case in other engines. The oil-box to the lower (main) end of the connecting-rod was bored up within a slight enlargement of the rod itself, and was thus wholly concealed from view. This cavity is filled with oil through a small opening in the side of the rod, and closed by a screw. The boiler of this engine was of large size for its power—three horse.

Among ordinary commercial engines, those of Messrs. Brown and May have taken the highest rank in economy of fuel in the trials at Bury last summer, and at Worcester in 1863. The reason is apparent in the use of longer and smaller tubes than are generally employed, by the invariable application of steam-jackets to the cylinders, and the use of the long slide-valve, giving very short steam-ports, and thus saving steam. This year these makers show an engine fitted with their patent feed-water heater, which they now apply without extra charge to all their engines of 8 horse power and upwards, and, of course, to smaller engines when paid for extra. This is a large cast-iron tube along the side of the boiler, and within this tube is one of wrought iron, through which the exhaust steam is taken at one end from a passage leading from the cylinder, and led off at the other on its way to the blast-pipe. The pump forces the water, under the full boiler pressure, through the outer cast-iron tube, and for its whole length in contact with the heating pipe. The feed-water is thus heated nearly to the boiling point, the pump working cold water as usual, so that its action is in no way interfered with. The saving is very considerable, quite up to the theoretical quantity, which is over 13 per cent. in heating feed-water from 62° up to 212°, and the saving of the firebox is at least in proportion to the saving in fuel. The upper surface of the cast-iron pipe of the heater is flat, and roughened with diamond-shaped projections, so as to serve as a neat foot-plate.

(To be continued.)

THE INSTITUTION OF CIVIL ENGINEERS.

At the meeting on Tuesday, the 10th inst., Mr. Charles Hutton Gregory, Vice-President, in the chair, the council reported that, acting under the provisions of Section IV. of the By-laws, the following candidates had that day been admitted as students of the Institution:

Name of Candidate	Recommended by
Charles Benjamin Braham	... J. W. Bazalgette.
Frank Samuel Braham	... J. W. Bazalgette.
Charles Capel Clatterbuck	... B. J. Ward.
George Selwyn Edwards	... Joseph Cubitt.
Thomas Archibald Fisher Hall	... William Baker.
Josiah Harding	... William Baker.
William Walton Williams, jun.	... Richard Moreland.

RAILS IN BELGIUM.—The administration of the Belgian state railways has let a contract for five lots of Vignoles rails, each lot comprising 425 tons. The lowest tender was that of M.M. de Dorledot Frères, of Acoz, who agreed to supply the lots at 5*l.* 10*s.* 2*d.* per ton. Only one English offer was made—that of Mr. E. Collins, of London, at 6*l.* 17*s.* 6*d.* per ton.

NEW ROUTE TO INDIA.

ENGLAND's best policy, with a view to keeping open her road to India, is undoubtedly to secure as much influence in Turkey, as well as in Egypt, as circumstances will permit; and nothing could well give greater advantages in that respect than to establish an overland route through Turkey, taking care to send a certain portion of our mails and stores by that line, and to maintain proper agencies, which should form centres of diplomatic action in case of necessity. We now learn that the Black Sea and Danube route is recommended to overland passengers. Negotiations are being made by the Porte with the view of attracting a share of the great stream of Indian traffic to a channel through its own dominions, and, for political purposes, such a desire on its part should be met in a kindred spirit by our own Government. In anticipation of a mail contract, the Austrian Lloyd's is building a steamer for the passage from Alexandria to Varna. At Varna a train waits to take the passengers on to Rutschuck, a distance of 140 miles, thence a steamer conveys them to Pesth, whence they may have a train to Vienna, and thence to England. The cost will be substantially the same as by Trieste or Marseilles; but the time will be shorter, and the scenery more varied and beautiful. An official from the London Post Office, who was sent to examine the capabilities of the route for mail-service, has reported favourably of it.

THE MARTIN STEEL PROCESS.

M. HENRI MATHIEU has recently communicated some interesting data on the Martin process to the French Society of Engineers. These data refer to the results of practical experience obtained at the works of M. Verdié, in Firminy, one of M. Martin's first licensees in France. The Martin process was started at Firminy on the 1st of June, 1867, and two Siemens furnaces have been kept in constant operation since that date, each capable of producing 3500 kil. (about 3½ tons) of steel ingots at a charge, two charges being made every twenty-four hours from each of these furnaces. The rate of production at Firminy is therefore about 80 tons of steel per week. The product is cast steel similar in its nature to crucible steel, or any other kind of cast steel made from raw materials of equal purity and quality. The principle of M. Martin's invention is the substitution of the reverberatory furnace for the crucible, in steel-making. M. Martin makes the bottom of his furnace to serve as a crucible. He follows a process similar to that in general use by steel-makers, i.e., the melting of cast iron with wrought iron and steel scraps, and with fluxes; and he only modifies his operations to suit the nature of his enlarged crucible. He cannot exclude the furnace gases, the same as the pot steel-makers do, by covering their crucible with proper lids; so he employs a quantity of very liquid slag to form a lid, and cover the surface of his metal. He further resorts to the Siemens furnace, which gives him, in the first instance, a clean flame free from noxious impurities, and which, moreover, allows him to adjust the nature and character of the flame from an oxidising to a neutral and even to a reductive flame, just as the stage of the process requires such changes. By these simple yet not easily discovered means M. Martin has succeeded in turning the bottom of his furnace into a cheap and suitable crucible for melting steel, and the practical result is a considerable economy in the manufacture of cast steel. The apparatus employed by M. Martin consists of a regenerative gas-furnace and two accessory furnaces, one for melting the pig iron, and the second for heating the iron scrap before its being introduced into the Siemens furnace. The pig iron, being brought to the state of fusion, is covered with a slag composed of charcoal blast-furnace cinders mixed with pure siliceous sand. The quantity of pig iron charged is 900 kil. The fusion being effected, and the flame of the furnace adjusted to a neutral character, a charge of 200 kil. of iron or steel scrap is introduced into the furnace. The scrap is raised to a white heat previously, and it takes about thirty minutes to melt down and combine with the liquid mass of the bath. In intervals of half an hour each, fresh charges of 200 kil. each are added in succession, and the entire operation occupies about eight hours, there being about two hours more required after each charge for fettling the furnace. During the sixth and seventh hours of actual working, after the addition of about 2400 kil. of wrought iron or steel scrap to the charge of 900 kil. of pig iron, the whole mass turns into a pasty state, approaching wrought iron in its character, but virtually neither steel nor wholly decarburised iron. This mass is then recarburised by additions of 200 kil. of pig iron at a

time, up to a total quantity of 800 kil. The pig iron finally added in this manner is of the same kind as that originally employed; it contains some manganese, and the quantity to be added to each charge is adjusted according to the quality or degree of hardness required. This can be done with great nicety, since it is practicable to take a small sample out of the steel bath from time to time, and, to test its quality, more pig iron or more scrap being added according to the test-samples' indications of a want or surplus of carbon. The bath being protected by the slag, the time of fusion may be protracted at will. There is no mechanical labour employed in this process, except in the operations of charging and casting. The pig iron employed at Firminy is that smelted from the Algerian ores brought from Mokta, and smelted in France. The scrap iron comes from similar raw materials, so as to avoid all phosphorus or sulphur in the iron, as these are only very little affected by the process. The Mokta ores contain a sufficient quantity of manganese for the purpose of steel-making by this process, and no other material is added to the charge. The steel made at Firminy is principally used for rails; it is of an excellent quality, and of a very ductile nature, both at high and at low temperatures. The cost of manufacture at Firminy is not greater per ton of steel made than the manufacture of steel by the Bessemer process, which is carried on at Terre Noire with iron from similar ores run direct from the blast furnaces into the converters.

INDIAN TROOP-SHIP EUPHRATES.

THE Euphrates arrived out at Calcutta on the 28th October, having left Suez on the 6th of that month. The heat in the Red Sea is described as having been very great; the maximum temperature observed was, on the lower troop-deck, 93°, and on the upper, 91° Fahrenheit—a difference which is inconsiderable, and may tend to allay the apprehensions that were entertained of this subject when the Jumna took on board the Rifle Brigade, and to which we alluded on a former occasion. Notwithstanding the actual heat of the portions of the ship occupied by troops, so effective was the system of ventilation on board that no inconvenience or injury arose even during the most trying part of the voyage, and both officers and men bore testimony to the uniform comfort they experienced on board. It is, however, not unlikely that in some particulars alterations may be required in the Euphrates and her sister troop-ships on the Eastern station: thus the cabins on the main deck may have to be altered, since, in their present condition, they are dark, and not so airy as might be desirable; there is also probably too much woodwork in connexion with the accommodation for soldiers' wives and children, iron being both lighter and better suited for cleanliness; and the amount of accommodation for the families of officers is certainly insufficient in the case of regiments coming home from India.

The Euphrates had been anchored off Prinsep's Ghaut in order that the Calcutta people might have an opportunity of visiting her. But during the cyclone of 1st. November she carried away her moorings, and was on shore for 4½ hours; she was, however, got off, but was found to be much strained from bumping. Her boats were stove in, and the saloon was deluged with water. It is reported that, had she gone a few hundred yards in another direction, she would have sunk and disappeared on Diamond quicksand.

THE KINNING PARK FOUNDRY.

WE have on a previous occasion mentioned the name of this establishment as a foundry entirely, and specially, devoted to the construction of plant for chemical manufactories, and particularly to the plant of mineral-oil works. Messrs. George Bennie and Co. originally established the Kinning Park Foundry for the production of very heavy castings occasionally required for marine engineering and similar purposes; but the great demand for castings of a peculiar kind, which at one time very suddenly arose in Scotland in connexion with the rapid spread of the paraffine industry and the manufacture of mineral oils, induced this firm to make this branch their speciality and exclusive work. Messrs. George Bennie and Co. soon found it of advantage to extend the mode of conducting their business, and to become engineers for oil works and contractors for the erection of machinery and plant. In this capacity they have planned, erected, and fitted out a considerable number of large works in this country and abroad. The Kinning Park Foundry is fitted out with the usual heavy and large-sized plant of foundries of this class. The cranes are all vertical pillar cranes, made of wooden framing, and

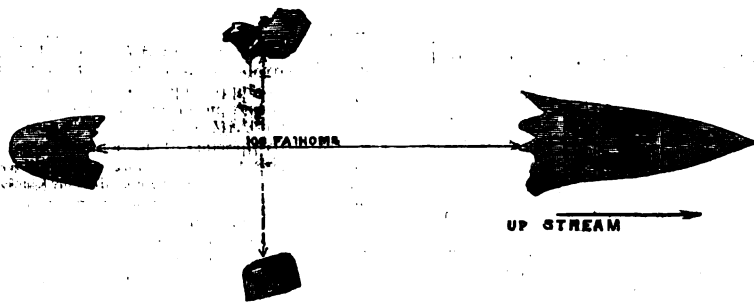
worked by hand, a clever arrangement of the handles allowing the vertical movement of the crane-chain and the horizontal travel upon the jib of the crane to be effected by the same workman, without his requiring to shift his position. The cranes are all capable of reaching each other. An unusually large number of drying-stoves is provided at this foundry, a necessity caused by the very large sizes and great numbers of the cores required for casting oil-retorts and stills. We shall, in our next number, illustrate some of the details of oil-distilling plant from drawings furnished by Messrs. Bennie and Co. The retorts and stills to which Messrs. Bennie and Co. give preference are different from those we described in connexion with Mr. Young's paraffine works. They advocate the horizontal retort, particularly when working up Boghead coal, or any other raw material very rich in oil and liable to swell in the retort. They also, from a very obvious reason, prefer the cast-iron still to the wrought-iron, although Messrs. Bennie and Co. are also makers of wrought-iron stills, but to a more limited extent. The cast-iron stills are large hemispherical vessels, covered with domes of a similar shape and material. Each still has a capacity of 1500 gallons, and weights, including the cover, about 7 tons. They are all cast bottom downwards, so as to get the advantage of the ferrostatic head or column for condensing the material at the bottom of the still. The moulding is done by hand, and without any pattern, the form being struck in the sand from a template, which is turned round the vertical axis. The cores are built up of brickwork, and covered outside with loam and moulders' sand. They are comparatively heavy, and the application of hollow cast-iron cores would probably prove of advantage. These brick cores, however, are easily built up, and not very expensive. They are all dried in the stoves, and afterwards inserted in the moulds, which also require drying. The solidity and fine appearance of the castings produced in this manner is a natural consequence of the great care bestowed upon all the operations in their manufacture, and there can be no doubt that articles of that kind are perfectly trustworthy in practice, and not likely to get out of order or to crack or break during their service. The mixtures of iron used for the different articles produced are considered great acquisitions at the Kinning Park Foundry, and they are always carefully registered and looked after. There are manufacturing purposes for which Messrs. George Bennie and Co. are considered to be the only founders capable of producing the suitable articles. An instance of that kind is the manufacture of iodine, which requires cast-iron stills. This branch of industry being confined to a very limited number of works in Scotland, it is understood that the Kinning Park Foundry holds a practical monopoly for the casting of those stills, as their mixture of iron is more durable, and wears more regularly, than the products of other foundries which have hitherto tried to make similar stills. The Kinning Park Foundry has four cupolas of different sizes, and an air-furnace capable of holding 60 tons of iron.

RANGOON AND CHINA RAILWAY.

THE first year's survey, by Captain Williams's party, within our own territory, an account of which we have recently given in full detail, is considered fatal to the project for a railway from Rangoon to China. The party surveyed the country for 245 miles, to our frontier, on the Pak stream, by the Beeling route, which they declare to present fewer engineering obstacles than that by Shoagheen, which is ten miles shorter. For the last 45 miles, however, the difficulties would be very severe, and the cost of a railway very great. There is nothing in our own territory to justify the construction of a line 1450 miles long, and it would seem that there is still less beyond. The Government of India has, nevertheless, sanctioned the continuation of the survey, this cold weather, to the Chinese frontier, if the political difficulties created in Western Karennee and the Shan States by the Mein-goon prince, who escaped from our surveillance, do not forbid it; but any further prosecution of the project has been deprecated. The question has now assumed a different shape. It is no longer that started by the Messrs. Sprye, of a railway 1450 miles in length, from Rangoon to China; but it is one of purely geographical exploration of the main routes between India and China. These are four: viz., the line partially surveyed already; the old caravan route by the Irrawaddy and Bhamo; the still older route through Cachar and Munnipore, by which the Buddhist missionaries penetrated Burmah; and the most dangerous but shortest route, from Suddya and the Brahmapootra to the Yang-tse-Kiang. When geographical parties have collected information regarding all these, it will be time to project roads and railways.

THE BUBULINA BOILER EXPLOSION.

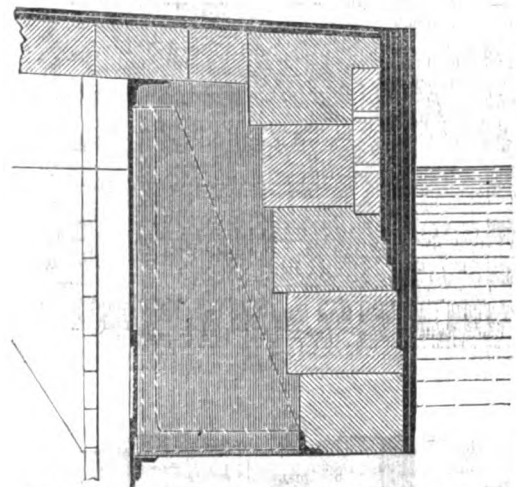
(See leading article, page 557.)

THE MONITOR QUESTION.
TO THE EDITOR OF ENGINEERING.

SIR.—With my letter, published on page 330, I sent you a tracing, copied from the official drawing of the midship section of the monitor Puritan. In a marginal note referring to it, from some cause I cannot understand, you said it was "really a lithograph," whereas it was simply a copy on tracing-cloth, like the inclosed one, taken as above stated, and creditably drawn by one of my assistants.

As you did not think proper to occupy so much of your columns as was needed to represent the entire midship section of the vessel, may I beg of you the favour to publish with this letter the enclosed tracing taken from the same drawing, showing a section of the "overhang" on the side of that vessel, and the dimensions and manner of armouring the same? Please let it be accompanied by the scale; so your readers may be able to measure the proportions for themselves.

I desire this sketch to go forth with the challenge to Captain Ericsson, to deny the paternity of it, and to say (if he have the temerity to do so) that it does not correctly represent the dimensions and arrangement of the armour of the Puritan and Dictator; and I desire him to deny, if he dares to, that the boasted 11½ in. armour of the Kalamazoo, and that class of monitors (the largest of them), is not made up in the same manner. I have not a drawing of the latter class convenient at this moment to refer to; but I believe the extra inch of thickness on them is made up solely by the difference in the horizontal thickness of the three bars placed behind the 6 in. plates, and does not involve even the addition of a single entire plate of inch armour throughout the depth of the side protected.



The whole point in issue between Mr. Bourne and myself is simply that I have charged him with persistently misrepresenting the thickness of the armour-plating on the hulls of the large monitors, and that in this unprofessional conduct he has been aided and abetted by Mr. Ericsson.

This course has been pursued to such a degree, and the real truth has been so studiously kept suppressed by them, that the public, almost without exception, really believe the gross deception. I have not attacked Mr. Bourne's arguments, but have protested against the misrepresentations he has made to give them an undue force. It will not avail him, when convicted of this grave charge, to resort to the puerile strategy of characterising my exposure as an endorsement of the Dunderberg. I am no advocate of that style of ironclad. Mr. Bourne, having been convicted of injuriously misrepresenting that vessel, now finds it necessary, in his endeavour to divert attention from one falsification, to make others, and therefore calls my last letter a "wordy dissertation in praise of the Dunderberg," when it does not contain one single sentence in laudation of that vessel. To what humiliating shifts does a departure from the truth bring poor human nature!

The information contained in this diagram has never been published. The purpose of your journal, and the love of truth which should pervade its columns, assure me that you will not withhold from your readers facts so important in correctly estimating the value of these vessels. It will be plain that their powers of resistance have been doubly overrated by the disreputable deceptions practised to secure the public approbation. By this means there is scarcely one of your readers on either side of the Atlantic but believes the armour of those vessels to be much heavier than that carried

by any vessel in the British navy, whereas 2 ft. below the water-line it is almost contemptible.

Mr. Bourne says, on page 357 of your journal, in reply to my letter:—"But with reference to the thickness of the sides of the Dictator, I have only to repeat that the delineation you formerly gave of that vessel, showing a total thickness of iron 10½ in. on the whole depth of the protected side, is the right thickness, and the alleged decrease in thickness in steps which Mr. Watt specifies is not correct."

My only reply to this statement is the diagram I inclose, and the challenge to Mr. Ericsson contained in this letter. My information comes from a source higher than Mr. Bourne's, it is from the official records of the Navy Department; and Mr. Ericsson must disprove it, or he and his friend will stand convicted of practising a gross deception upon the public.

Mr. Bourne thinks the "monitor question" is exhausted, and as there is no one in opposition to it, worth replying to, he states that he has retired from the field. The public will doubtless envy the serenity with which he will permit this communication to remain unnoticed.

WM. WATT, C.E.

Washington City, Nov. 14, 1867.

[We much regret the severity of the tone with which Mr. Watt discusses this question.—Ed. E.]

SEWER VENTILATION.

UPON the subject of sewer ventilation, which is likely to acquire great importance in London especially, the late report of the Metropolitan Board of Works contains only the following brief remarks:

"In their last annual report the board adverted to experiments which, by their direction, had been conducted with a view to assist them in deliberating on this important question, and they have now to report that, during the past year, further experiments have been made by their engineer and Dr. Miller in order to test the efficacy of a plan for destroying, by means of charcoal ventilators, the offensive gases emanating from the sewers. In the reports on the subject, which have been recently submitted to the board by those gentlemen, the nature of their experiments is described, and an opinion expressed that the result has sufficiently demonstrated the efficacy of charcoal grates as a means of deodorising the noxious gases to justify the prosecution of additional experiments of the same nature, but on a more complete and extended scale, with a view of still further testing the principle and its general applicability. The board have reason to think that these experiments will materially help them in arriving at a decision as to the most effectual means of preventing the nuisance occasioned by the escape of offensive gases from the sewers of the metropolis. The reports above referred to are given in Appendix No. 3 to this report."

THE CUSTOMS EXAMINATION OF LUGGAGE.—It is reported, in connexion with the examination of the luggage of passengers from the Continent at Charing-cross Station, that some of the Custom-house officials are endeavouring to induce the Board of Commissioners to return to the old system of having one piece in every lot examined, instead of, as now, only one or two pieces in every 10 or 20 lots. The present method saves time, and is an accommodation to the public. It is believed also to work extremely well. Hence, unless the Board are prepared to justify the proposed backward step as a matter of imperative necessity, it is likely to be met by a general protest from all the travelling and commercial classes.

RAILWAYS IN RUSSIA.—A letter from Moscow states that the second section of a line of railway from Moscow to the south has been opened for traffic. The first section, from Moscow to Serpoukhoff, 59½ miles, was opened for traffic last year; and the section now opened extends from Serpoukhoff and Toulá, 58½ miles more. Traffic is thus now conducted over a distance of 112½ miles. The third section, between Toulá and Orel, and the fourth, from Orel to Koursk, will be opened to the public next summer. The heavy works are finished over the whole distance; the construction of the station buildings alone delays the commencement of traffic. It is also considered prudent, in order to assure the solidity of the way, to allow the embankments to stand before commencing traffic upon them.

SOUTH YORKSHIRE.—The South Yorkshire iron trade appears to keep up pretty well; there is not, however, so much doing in plates or sheets. For steam coal the demand shows a considerable falling off; house coal, however, is in brisk request, not only for London but for the various drops on the Great Northern Railway. About an average business is being done by the Manchester, Sheffield, and Lincolnshire Railway with Lancashire, principally in engine fuel and secondary qualities of hard coal.

UNCHARTERED SCIENTIFIC BODIES.

It is singular that, during the jealous and unworthy opposition made to the attempt of the Society of Engineers to obtain powers to hold property of their own, the Act of August 11th, 1854, was not discovered. This Act is, we believe, scarcely known to the heads of scientific bodies, yet it effectually empowers such bodies with all the rights and privileges of corporate institutions. We extract three of its clauses, which will indicate the scope of the whole:

"XXI. Any Institution incorporated which shall not be entitled to sue and be sued by any corporate name, and every Institution not incorporated, may sue or be sued in the name of the president, chairman, principal secretary, or clerk, as shall be determined by the rules and regulations of the Institution, and, in default of such determination, in the name of such person as shall be appointed by the governing body for the occasion; provided that it shall be competent for any person having a claim or demand against the Institution to sue the president or chairman thereof, if, on application to the governing body, some other officer or person be not nominated to be the defendant.

"XXV. Any member who may be in arrear of his subscription according to the rules of the Institution, or may be or shall possess himself of or detain any property of the Institution in a manner or for a time contrary to such rules, or shall injure or destroy the property of the Institution, may be sued in the manner hereinbefore provided; but if the defendant shall be successful in any action or other proceeding at the instance of the Institution, and shall be adjudged to recover his costs, he may elect to proceed to recover the same from the officer in whose name the suit shall be brought, or from the Institution, and in the latter case shall have process against the property of the said Institution in the manner above described.

"XXXI. For the purposes of this Act, a member of an Institution shall be a person who, having been admitted therein according to the rules and regulations thereof, shall have paid a subscription, or shall have signed the roll or list of members thereof; but in all proceedings under this Act no person shall be entitled to vote or be counted as a member whose current subscription shall be in arrear at the time."

THE METROPOLITAN DISTRICT RAILWAY.—The Metropolitan District Railway Company have invited tenders for 500,000l. six per cent. debentures at noon on the 20th instant. This will enable the company to complete that portion of the line from Kensington and Brompton to Westminster-bridge—about five miles—by midsummer next, and also to prosecute vigorously the works from Westminster to the city. The tenders for the above bonds are to be at or above par, which is fixed as the minimum. The share capital over which these are to ride is 2,250,000l.

EXPORT OF RAILWAY IRON FOR THE EAST INDIES.—The export of railway iron from the Clyde to the East Indies during the last four months has been very large. Three specially chartered ships have been sailing almost every month for Bombay, the central part of the railway operations now going on in India, in addition to others taking general goods and a few hundred tons of iron. Of those specially engaged for the conveyance of railway chairs, tie-bars, &c., there was the Jane Leech, with 1080 tons; Sea Pink, with 1341 tons; Tim Whiffler, with 1375 tons; Otogo, with 500 tons; Martaban, with 650 tons; Ardgowan, with 1000 tons; Hannah Law, with 1850 tons; West Riding, with 1402 tons; and Ann Fleming, with 1290 tons; total, 10,680 tons.

THE GLASGOW MALLEABLE IRON TRADE.—The first annual soirée of the persons connected with this trade in Glasgow was held last week in the Merchants' Hall. Mr. Robert Murdoch, iron-merchant, presided. In the course of his address, the chairman traced the history of the manufacture of malleable iron in Scotland. It only began some thirty or thirty-five years ago. About that time the Muirkirk Ironworks (now the property of the Messrs. Baird, of Gartsherrie) were constructed, and might be considered as the oldest works in which crude iron was converted into malleable iron, although many years previously hammered-iron was manufactured in very small quantities, and intended as a substitute for Swedish and Russian, which for a long time were the only varieties of iron used for engineering and blacksmith purposes. Long before this, however, attempts had been made to start the trade, and large amounts of money were expended in the erection of works which had to be shut up, on its being found that they were in advance of the age. The first works of the kind were understood to have been the Carron Ironworks, but it was not known that they went further into the trade than making a small quantity of forgings, such as cart axles, &c. Early in the present century a family named Wilson, extensive London merchants, erected works upon their estate at Wilson-town, between Carlisle and Shotts, spent a lot of money, but made no progress. Their works were gradually dismantled, the estate falling into the hands of the Dixon family, in whose hands it still remained, and he believed part of the rolling machinery or engines still existed at Govan Works. About thirty-five years ago the late Mr. Dixon, along with a Staffordshire ironmaster, started a malleable ironwork at Townhead, but it had a very short existence. A few years later, however, Mr. Dixon resuscitated this work, and carried it on successfully until the present Govan Bar Ironworks were erected, when the Townhead Works were entirely dismantled. The next malleable ironworks erected were those of Dundymon about 1836, and he was very sorry to learn that they were now standing, and apparently were very likely to be broken up. A year or two later the Monkland Iron and Steel Works started, and then there was a pause for some years. In 1846 the Glasgow Iron Company started their Glasgow Ironworks at St. Rollox. About the same time, the Motherwell Ironworks were commenced, but they did not good until they fell into the hands of the Glasgow Iron Company, which now deservedly stood at the head of the malleable iron trade in this country. Six years later the Blochairn ironworks were erected, and this completed the number of the large works.

HIGH-PRESSURE MARINE BOILER. AS CONSTRUCTED BY MESSRS. ROWAN AND CO., ENGINEERS, GLASGOW. (For Description, see Page 545.)

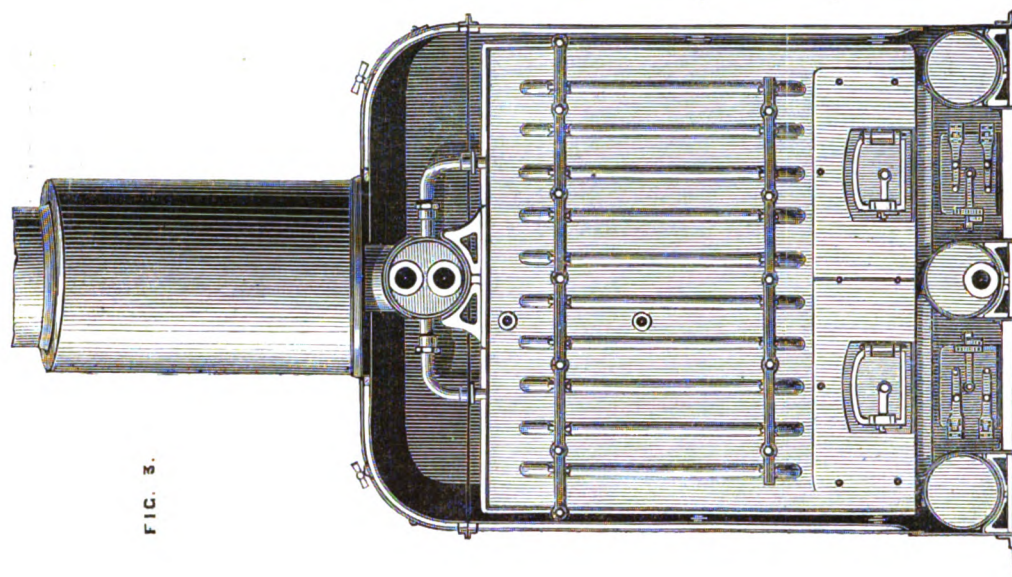


FIG. 3.

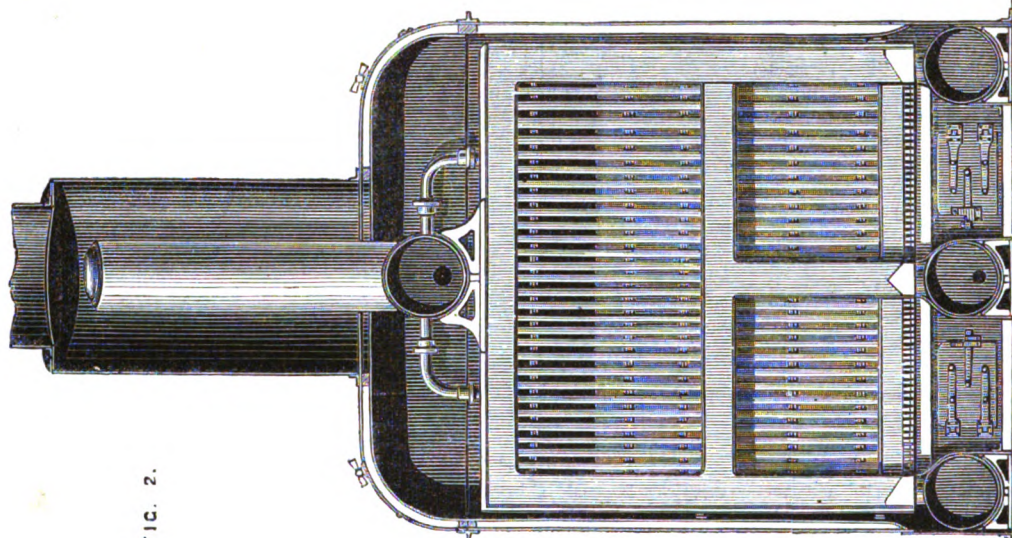


FIG. 2.

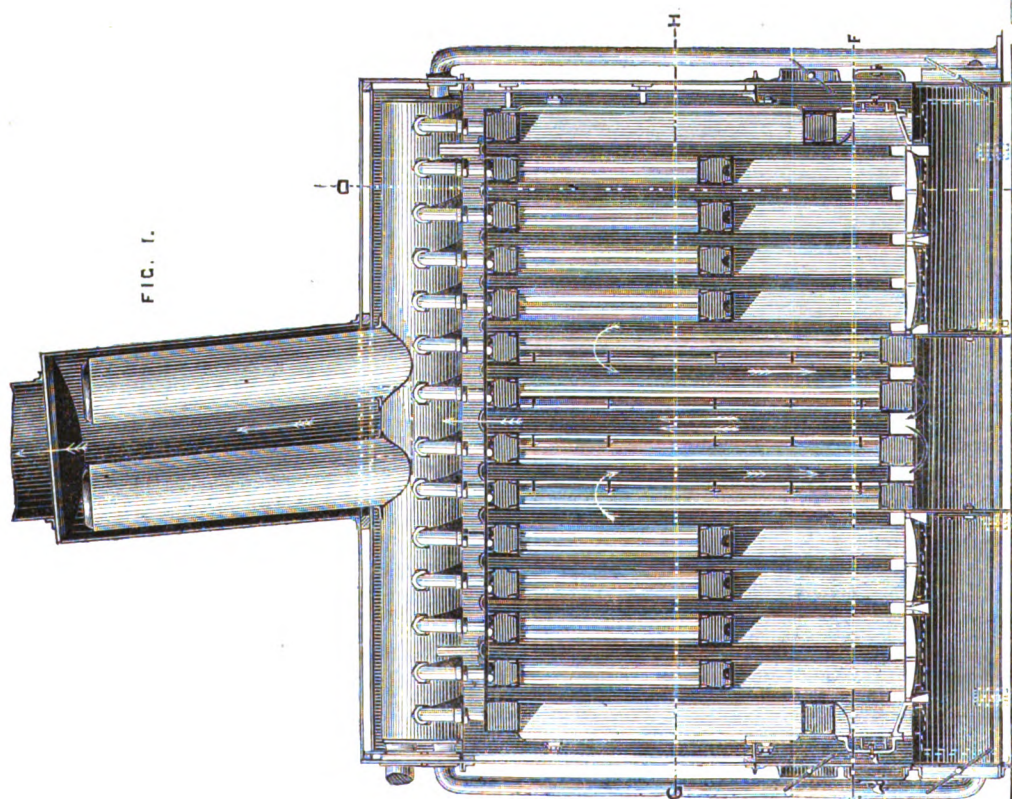


FIG. 1.

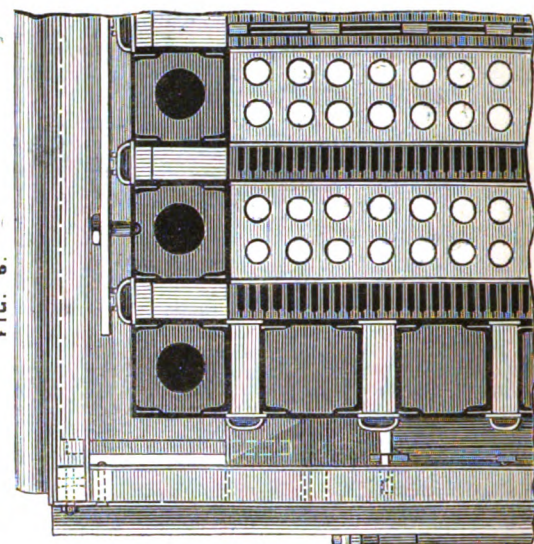


FIG. 6.

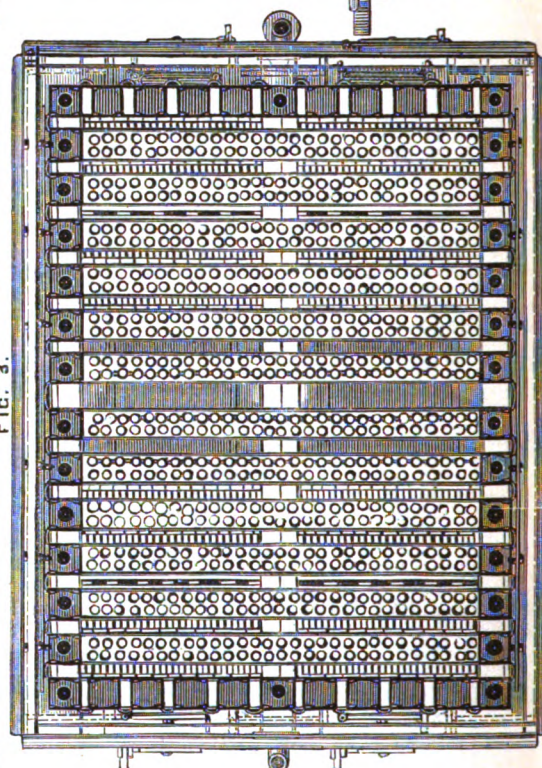


FIG. 3.

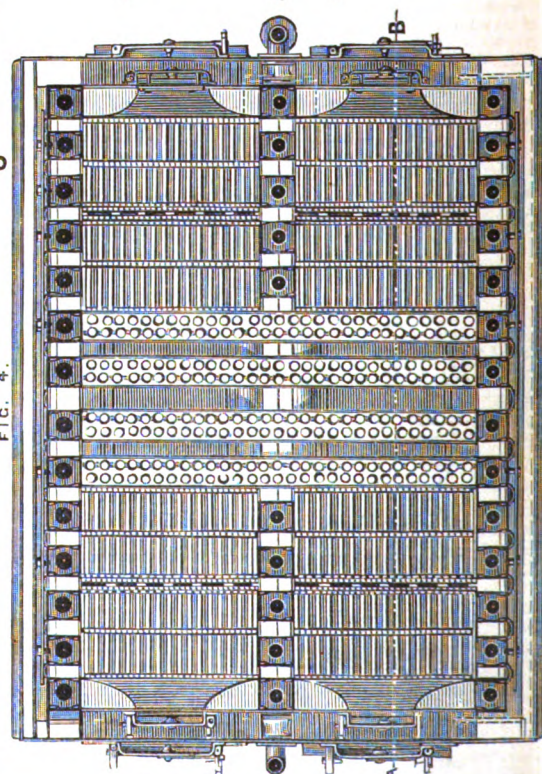
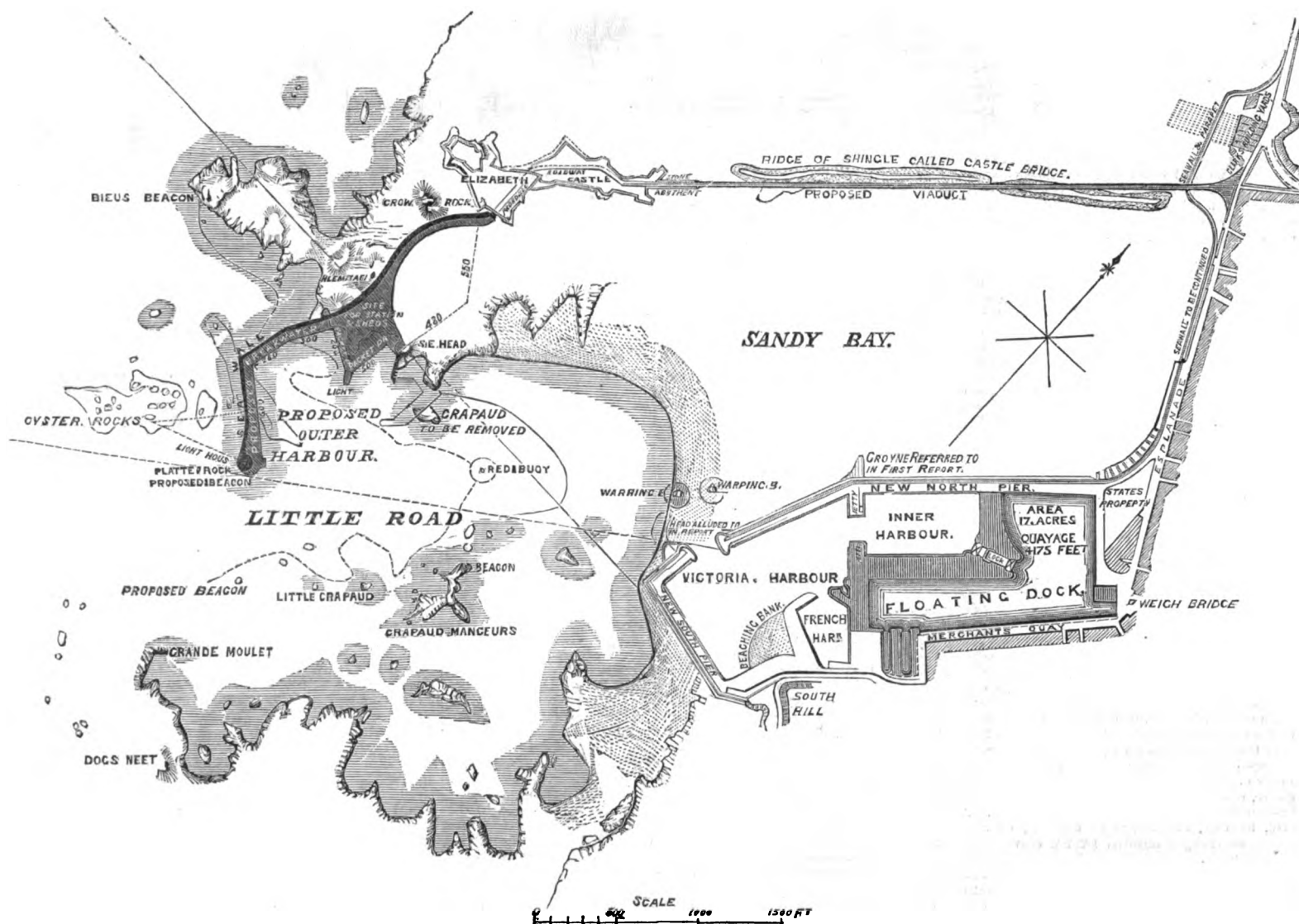


FIG. 4.

THE HARBOUR OF ST. HELIER, JERSEY.

REPORT OF MR. GEORGE FOSBERY LYSTER, ENGINEER TO THE MERSEY DOCK BOARD.



We subjoin Mr. George Fosbery Lyster's report on the harbour of St. Helier, Jersey, referred to in that gentleman's letter, which appeared in our last number, page 523. Just now, when the various plans for the improvement of the harbour are under consideration, the report will be of much interest.

Guernsey, November 15th. 1860.

Sir,—Your letter of the 25th August last, enclosing a copy of a petition, addressed to the Chamber of Commerce of Jersey, by the gentlemen representing the interests of the Steam Navigation of that island, was duly received.

That document informed me that the plan and report, which I had the honour to submit to you in May last, recommending the construction of floating and graving docks within the existing harbour, with such external works as its present unsheltered condition demands, though fully approved by your committee, and agreed to by those who signed the petition, can nevertheless only be considered by the latter as an instalment of what should be done for the development of the commerce of the island.

These gentlemen first consider that the extra outlay required to double the graving dock, by building it of twice the width, with a middle wall, so as to have two docks, side by side, would be a judicious extra outlay, and in the end would be amply repaid. They further consider that the accommodation for steamers will be totally inadequate to the wants of the increasing steam shipping of the port; and as the interests of the town and island are inseparably bound up with the encouragement of this branch of your trade, they think that hardly any outlay can be considered too great which has for its object the development of the passenger traffic on the largest possible scale, and also the facilitating the transit of such exports as require the expedition of steam shipping to make them valuable as objects of commercial speculation. They, therefore, suggest that, in lieu of the small and inexpensive low water steam-boat harbour, proposed in my report to be carried out, from the rocks in the neighbourhood of Elizabeth Castle, that a harbour suited to all states of the tide be constructed (and rightly conjecturing) that a similar position would be chosen for the larger work. They further recommend that it be connected with the Esplanade by a high level causeway, having as many bridged openings as may be deemed necessary, one of which they consider should be a draw-bridge, to allow of vessels being towed into harbour from the various building-yards along the St. Aubin-road.

Taking these requirements as a basis, you requested me to proceed to Jersey as early as convenient, and to take the necessary measures for the attainment of the object in view, and at the same time you informed me that, if possible, the estimate

for the work, conjointly with that already approved, should not exceed some 150,000£. or 160,000£.

On the receipt of your letter, I lost no time in preparing a survey of the shore forming the boundary of the "small road," and taking such soundings as were necessary to enable me to form a well-matured opinion as to the proper position for the works in question. In the operation of sounding, I was kindly assisted by Captain Sidney, R.N., of the Hydrographic Department of the Admiralty, who, being employed in preparing a survey of the Channel Islands, kindly consented, with the sanction of Captain Washington, the hydrographer, to take such soundings as a preliminary inquiry demanded. These, combined with the accurate delineation of the shore and off-lying rocks by my own assistant, as well as a careful personal examination of the locality during my stay of three weeks in the island, and during weather of extreme severity, have enabled me to design the plan which accompanied this report.

I may here be permitted to remark that I have considerable diffidence in approaching the subject under consideration, as I feel assured that in the whole range of questions relating to harbours, few, if any, present features more difficult to deal with than those of St. Helier. We first have the opposing physical conditions of the locality to contend with, and these are of no ordinary character, viz., a tidal range of upwards of 40 ft., and consequent currents of extreme velocity, a narrow and confined roadway approached by intricate channels, and open to the uncontrolled range of the seas from the Atlantic Ocean, and further exposed to the prevailing winds which blow six months out of the year, an open and extended length of shore to traverse to meet the margin-line of low water, a distance of some miles to convey face-stone suitable for constructive purposes. These, combined with the natural wish of your committee to limit the expenditure to a minimum, and the ever-obtruding consideration of the large sums already expended in procuring what at best may be termed but very partial and inadequate accommodation, makes the matter of carrying out your instructions one of no ordinary difficulty.

Yet with all these elements of opposition, I cannot but think that your committee have acted wisely in endeavouring to make the best of the present position rather than seek elsewhere a locality which, though probably more favourable for the construction of a harbour, would, under existing circumstances, I feel assured, prove highly inconvenient and prejudicial to the best interests of your rapidly increasing town and trade, and could only be carried out at a cost much beyond what I conceive to be your local resources. I mention this with more confidence as I find, from the examination of the small road, that its capabilities are amply sufficient for the present or prospective requirements of your trade, and, if properly turned to account,

will not only afford an excellent floating harbour within itself, but the works involved thereby will give all the shelter requisite to render the present harbour safe and convenient.

In preparing my design, I have been careful to include as much of the roadstead and adjoining clear anchorage as is available for harbour purposes, and though in doing so I may have exceeded the figures laid down in your instructions, I think it desirable that your committee, and the public generally, should be made fully acquainted with the capabilities of the locality, and, if they see fit, dictate modifications, rather than that I should propound a scheme which might hereafter be found insufficient.

In my plan of the 23rd May last, my instructions led me to deal only with the question of furnishing the present harbour with floating and dry dock accommodation. These involved extraneous works, which, with the exception of the low-water pier and tramway, were valuable solely as a means of sheltering the harbour entrance and securing the safety of the dock. In the plan now under consideration, these works would no longer be necessary, so that the sum recommended to be expended upon them, viz., £1,654^l, would be absorbed by the works of which I now treat.

The plan I have to propose is, to cover in the small road by a breakwater which would project from the rocks at the south of the castle, and by its peculiar form would enclose all the clear anchorage which the soundings indicate as applicable for harbour purposes.

The first step towards this object will be that of budging over the space between Elizabeth Castle and the shore, a scheme which, even without the ulterior object of leading to a new harbour, has, I believe, been long in contemplation for the purpose of making the castle available as a barrack.

To span the gap with a solid roadway, protected by properly constructed stone walls, would involve so large an expenditure as at once to place it beyond the limits of the present inquiry. But, setting aside this consideration, it is probable that a work of such a character might so derange and increase the velocity of the tidal currents, as to render it difficult for vessels to enter or leave the roads; and further, by doing away with the flow of the tides through their natural channels, might induce a deposit of silt to accumulate within the enclosed space, which, in course of time, would have the effect of destroying the harbour.

These important considerations lead me, therefore, to recommend a bridgeway as not only the cheapest, but also the best means of meeting the difficulty, and keeping intact the existing condition of the roadstead.

It is almost needless to observe that any work for such a position should be constructed of the best and most durable

materials, and in the strongest possible manner, as the seas through the gap are sufficiently formidable to deal very roughly with any obstruction that may be opposed to their free action.

I therefore consider a structure of stone or timber to be inapplicable for the purpose, and have concluded that a bridge of wrought iron is that best adapted to the locality, as the nature of that material is such as to admit of its being framed in large spans, so as to offer but little opposition to the wind, and the consequent few intervening piers will but slightly interfere with the action of the sea, while its durability is superior to either timber or cast iron.

In a preliminary report it will only be necessary to describe the leading features of such a work, and even these I reserve as open to such alteration or modification as a closer examination of the subject may dictate.

I have arranged the position of the viaduct to be as nearly as possible coincident with that of the ridge of shingle called the "Castle Bridge," as it is but natural to suppose that along that line some neutral action of the current takes place which tends to keep at rest that accumulation. Besides which, the position offers a line of direct communication between the castle and the heart of the town, through that highly improved suburb which, I understand, is but of late arrangement.

In order to cut off any tendency to a run of sea along the esplanade during south-westerly gales, I have shown a stone abutment to project for a length of 300 ft. beyond the general line of shore, connected with the existing walls by wing walls of easy curves, unless the arrangement described by the yellow tint on the plan, and referred to hereafter, be considered more desirable.

The bridge, as I before stated, I propose should be of wrought iron, as light as possible in appearance and construction, consistent with strength and stability. The roadway to be 25 ft. wide and 12 ft. above the level of the highest tides, a height amply sufficient, as the structure would offer no impediment which would tend to break the passing seas. For this reason I have designed the piers to be constructed of groups of cast-iron columns deeply screwed into the solid ground and strongly braced with wrought-iron ties, all the ironwork of the piers to be galvanised so as to counteract the injurious action of the salt water.

The spans between the piers to be 95 ft. wide, and every fifth opening to be terminated by a strong stone pier, which would not only add to the lateral stiffness of the work generally, but would admit of the construction of steps to lead to the sands, and also the accommodation of seats.

On the castle side I have shown a stone abutment to project 400 ft. from the entrance, at which point it is proposed that the ironwork should terminate. This projection will, I consider, materially assist in quieting the entrance to the present harbour, as by it the south-west seas, which now wrap round the north side of the castle, will be induced to glance off towards the centre of the channel rather than towards the harbour mouth.

In this design I make no provision for a drawbridge for the passage of vessels, as such a construction would add materially to the expense, while in the end I feel assured it would fall into disuse, more particularly as I understand it is intended that the harbour should be provided with a tug steamer. A work of the kind, however, can always be added if, on consideration, it should be thought essential for the convenience of the ship-building trade.

To avoid the heavy and costly construction of a causeway outside the castle walls, I venture to suggest that permission be solicited from Government to be allowed to make use of the roadway through the castle, so as to arrive at the exterior work, as by that means a large saving would be effected; and, though quite unacquainted with the requirements of Government in such cases, it appears to me, as far as I can judge, that no injury would thereby accrue to the defences. A strong palisading, or other such barrier, might be erected on either side of the road, fitted with gates and doors where required, and thus the isolation of the barracks and adjoining buildings would remain as perfect as at present.

Premising that such a petition might be favourably regarded, I have framed my design in accordance with these views, and propose to make use of the present roadway through the castle, and along the north side of the barrack square in front of the canteen, to a point near the south-east bastion. There I propose a gateway should be formed through the wall, and the roadway connected with the exterior work by a drawbridge. From that point I have designed a causeway to extend in a southerly direction seaward, formed to a radius of 550 ft., with its convex face towards the south-west weather—a position which will admit of the work being carried along that part of the shore most favourable to the economy of construction. The inner wall is shown to extend in a regular curve to the high point, which I have designated the "South-east Head," against which I propose it should terminate.

At the point where the outer wall will abut the Hermitage Rock, I have designed that the curve for that work should be reversed, and propose that it should be thus extended to the margin line of low water at a radius of 800 ft. Though this arrangement at first sight might appear to offer a weak and concave form to the sea, on examination of the locality it will be found that the high bluffs of the Hermitage and adjoining rocks will thoroughly protect the work from any injury.

From the shore line, the breakwater is shown to extend seaward in a south-west direction for a length of 180 ft., so as to cover the rocky heads which project above low water along that line.

Here the alignment is altered to a more southerly direction and so continued for a length of 880 ft., and as a further extension seaward would involve enclosing rocky ground, without any corresponding advantage of additional shelter, I have designed that the breakwater be there kanted to a south-east bearing, and continued in that direction for a further length of 600 ft. to its terminating head, the last 800 ft. being concave and slightly inclined towards the south, so as to throw off the south-west seas rather than induce them to search into the roads. From the inner side of the head a spur is shown to project for the purpose of cutting off any run of the sea along the adjoining berths.

As it is very important in designing works of this description

so to arrange the principal berths as to admit of an easy approach and departure for the long steamers now gradually coming everywhere into use, and soon likely to replace the smaller class of vessels on this station, I have endeavoured to arrange a packet pier which will afford these facilities, without, at the same time, occupying too much space within the harbour. This the very favourable soundings and contour line of the shore has enabled me to accomplish by projecting a quay wall, to return at a right angle from the inner wall of the breakwater near the point where it leaves the shore, and extend eastward and parallel to its rocky margin for a length of 300 ft., being terminated by an arm 80 ft. in length, projecting therefrom at an obtuse angle. The embayment of the shore near this point has also enabled me to design a similar quay, to return from the head, northwards, for a length of 300 ft., and be terminated by a short wall, to project at a right angle, and tie into the "South-east Head." Abreast of this rock I have shown a row of fender piles to be fixed so as to secure a ship from accident should she fall off from her moorings. I have also shown in dotted lines a means of extending the accommodation, should such ever be required.

The height of the parapet of the outer wall of the breakwater I propose should be 17 ft. above the highest tides, covering a terrace 15 ft. in width, with a quay wall and roadway 55 ft. wide. The level of the quays to be similar to that of the existing quays of the present harbour.

I further propose that the arrival and departure berths should be furnished with timber stages, recessed within the general line of walls, and provided with decks at different levels to suit the tides. The soundings generally throughout the harbour space show an average depth of about 14 ft., with here and there unfrequent patches of 10 ft. They are reduced to the level of the lowest low water, so that the depths expressed on the plan would, in reality, only occur once or twice in the year during the low water of an equinoctial spring, so that generally the depth of water in the harbour would be more than sufficient for the class of steamers likely to frequent the port, of which the new vessel, the Southampton, drawing 9 ft., may be regarded as the probable type. The patches, however, being evidently caused by heads projecting through the sand, could at any time be uprooted at no great cost, if found to interfere with the convenience of the harbour.

The breakwater encloses an area of 10 acres, which may be said to be perfectly sheltered in any weather, and the length of quayage amounts to 1770 ft. The lozenge-shape space of ground included between the approach walls and quays of the Packet Pier, near the Hermitage, will be sufficient and well adapted for the construction of a station, goods shed, and coal depot.

Should the breakwater be carried out as herein described, I think it very unlikely that any alterations would be required at the head of the present South Pier, as I believe the proposed works would sufficiently shelter that entrance. I have, however, designed a projection which might be required should southerly gales be still found to affect the quiet of the harbour; but such a work could at any time be constructed, and experience would be the best monitor as to its necessity; I have not, therefore, deemed it so essential as to include it in the estimates.

In considering the position of the breakwater head, I have been careful to avoid as much as possible interfering with the easy approach or departure of vessels from the harbour, and have endeavoured to keep the mouth so open to the direction of the line of clear entering as to leave intact the main channel, having at the same time due regard to the shelter of the internal works. It is true that by the proposed arrangement the inner passage between the castle and the shore would become closed; but in works of this description—more particularly in a locality such as that in question—it is impossible to devise a plan clear of all objections, and this should be regarded as a minor matter amply compensated for by the extra amount of shelter and accommodation afforded by the works generally, rather than as an impediment to their execution. Besides which, the bridge passage is only required when the wind is in such a position as to make it difficult for a vessel to work out through the narrows between the harbour entrance and the castle rocks, and then only in fine weather and at high water; and under the present plan it is considered that the shelter and smooth water insured by the breakwater would admit of a vessel being easily worked or warped to the new head from which she could take a slant seaward free of all dangers, though the most expeditious way of clearing out would be by means of a tug steamer, the necessity of which has been so long admitted.

The dotted red line on the plan shown to extend from the entrance of the present harbour past the breakwater head, and tangent thereto, will sufficiently explain the extra amount of shelter gained, viz., 280 ft. by the proposed form of work over any projection carried from the castle in a direct line to the "oyster rocks"—a work which would not only involve greater difficulty in clearing the port, considerable increase of estimate by reason of its greater length and exposure, but also would afford no sheltered position in southerly gales, and with the wind at all from that direction would so expose the "quay berths" along its inner face as to render them insecure, if not impracticable, while at the same time it would enclose numerous shoal patches and rocky heads.

From the tenor of my last instructions—emanating as they do from the gentlemen representing the steam shipping interest of the island—it might at first sight be inferred that a floating harbour is proposed solely with a view to the accommodation and convenience of the steamboat trade; and though, from the peculiar requirements of that class of vessel, such might fairly be regarded as the *prime object* of the outer work, I certainly consider that sailing ships would also largely partake of its advantages; and I cannot but think that the interests of the two, as regards harbour accommodation and convenience, are inseparably bound together, as what is of value for the one must be of considerable advantage to the other; or, to reduce it to example, I consider that the construction of a wet dock without a floating harbour would ultimately prove as incompatible with the general interests of the island as the construction of a floating harbour without a wet dock. Thus, supposing a sailing ship, bound to St. Helier, should arrive off the island in the evening in a rising gale from the south at a period of tide which precluded her entering the port—say in the ebb, with only

5 ft. of water between the pier heads—she would have to beat about all night, or run round to the lee side of the island for shelter, and thus lose time, and incur perhaps more risk than on any other part of the voyage; whereas with a harbour, such as proposed, she could run in and take up a berth until she found water enough to admit of her entering the dock. To vessels leaving the port, it would be found equally useful, as they might hail out from the dock, and remain in the roads, or sheltered water within the harbour, until it was convenient to clear out, or it might be until the tug steamer was disengaged.

To steamers, it cannot be denied that the value of such a work would be incalculable, as the short time they remain in port, and the particular hours they have for sailing, will always preclude their entering the dock; and without a floating harbour they would be subject to the grievous necessity of grounding every tide, which is admitted on all sides to be a fruitful source of damage both to hull and machinery. In fact, the arguments in favour of the steamers state that the alleged necessity of a wet dock for sailing vessels is a convincing proof of the imperative necessity of a floating harbour for steam ships, as, being a longer and sharper class of vessel, with heavy weights of machinery unequally distributed throughout their length, they are more liable to damage by grounding than the shorter vessels with well-stowed cargo. And further knowing, from the peculiar circumstances of the existing harbour, that the construction of wet docks would involve costly extraneous works solely for the purpose of shelter, they naturally demand that those should be of such magnitude as to meet their peculiar requirements. I deem it here unnecessary to dwell on the convenience such an arrangement would afford to the passenger public, as such must be self-evident to even the most casual observer.

As a look-out station for Government, close under the range of their own forts, and convenient for landing and embarking troops and stores, or coaling and sheltering the smaller class of ships of war and gun-boats, it appears to me that the position and plan are well adapted, and should be regarded as most valuable, being the only harbour in the island where vessels could in any weather, and at all times of the tide, come alongside a quay. It might be therefore that, considering the advantages that would accrue to the public service by the construction of so useful a work, Government would not only accord free permission for the use of the roadway through the castle, but at the same time might deem it advisable to expedite the completion of the works by either a loan on favourable terms, or a free grant of part of the outlay, more particularly that portion relating to the connexion of the castle with the shore, which would render the barracks there always available.

Having thus stated, at perhaps greater length than may be thought requisite, my views regarding the harbour scheme generally, I may here add a few remarks in explanation of the method and character of work I propose should be adopted, and upon which I have based my estimate; and in doing so, I feel it almost needless to add that, considering the extent of your requirements, and my recommendations, with the comparatively limited sum proposed for expenditure, I have been compelled to assume that the strictest economy should be observed in all classes of the work consistent with strength and efficiency.

First, as regards the main breakwater. To carry out such a work to the state of completeness shown upon the plan, viz., with inner quays, terrace, and roadway, would be quite beyond the limits of the sum proposed; I therefore have to recommend that the outer or sea-wall be first constructed for its entire length to a height of 5 ft. above high water, and backed with the rough filling obtained from the adjoining rocks, which would be allowed to assume the natural slope due to such material. The barrier thus erected would shelter the roadstead and harbour as effectually as the more costly breakwater, complete in all its details, while the inner walls might be leisurely proceeded with, according as the requirements of trade or local funds permitted. A work of this description must needs be of the strongest possible character, and for that reason I have designed it of such dimensions as would amply insure its safety.

For the immediate demands of the steamboat trade, I propose that the so-called "packet pier," with its recessed stages, be completed at once, so as to afford convenient berthing for two or three vessels, which, with some temporary arrangement in timber under the lee of the breakwater, would doubtless give sufficient accommodation pending the completion of the quays.

The character of masonry I have to recommend for the entire works is similar to that I have adopted so successfully and economically in Guernsey, viz., for the facework, large blocks of granite of irregular form, such as arise in the process of quarrying, hewn on the beds and joints to regular planes, and fitted so as to bond into each other without presenting any length of horizontal joint to the lifting action of the sea. This I propose should be backed with selected stone of the largest procurable size from the rocks in the neighbourhood of the castle, or from the high land called "Gallows Hill" near the town, which would appear to afford a ready supply.

Such work, properly bonded and consolidated with good mortar from hydraulic lime, seems to be even stronger, and in appearance more pleasing to the eye, than the costly or more formal work composed of squared materials. The only difference to be made in the sea-wall masonry from that of the quay or dock would be that the face stone of the former would remain rough as quarried, while the latter would be fair dressed.

The filling for the breakwater I propose should be procured from the rough rocks under the eastern lee of the approach walls and castle, which, if excavated sufficiently deeply, might afterwards be covered with sand and shingle, and thus make a convenient beaching ground for vessels and fishing boats, while, at the same time, the half-tide capacity of this part of the harbour would be conveniently extended for vessels working out.

To make the design more complete, a beacon should be erected on the rocky heads on each side of the entrance, so as at all times of tide to indicate the channel. These, however, I have not estimated.

On the plan which accompanies this report, and in accordance with the wishes of the gentlemen representing the steam shipping interest, I have designed a second graving dock, adjoining that already proposed in my report of the 23rd May last, but it is not included in the following estimate, owing to the unavoidable

excess of my figures over those dictated in your instructions. It can be added, however, should your chamber deem it expedient. On the same plan I have also reproduced my former design for the docks, as I see no reason for deviating from the views therein laid down, with the exception of the pier-head designed to overlap the entrance to the "French harbour," which, with the outer works now recommended, would doubtless be unnecessary.

It now only remains that I should give an estimate of the works described in this report, having based my figures on the mode of construction above described. To this I have added the modified estimate for the previously proposed improvements in the present harbour.

Cost of external works, viz., viaduct and approach walls, roadway through Elizabeth Castle, draw-bridge, causeway, to packet pier, &c., and break-water	£ 114,338
Cost of internal works for the improvement of the present harbour, viz., floating dock, tidal basin, jetties, and inner harbour, with the modifications herein alluded to	71,175
Graving dock	13,165

Total 198,678

In the early part of this report, in alluding to the position of the land abutment of the proposed viaduct, I mentioned an alternative plan (coloured yellow on the drawing) which, though quite extraneous to harbour improvements, I consider is not unworthy of the attention of your chamber.

From the frequent conversation I have had with friends and others who have visited your island, I have been led to believe it is generally considered that the hotel accommodation of St. Helier is neither sufficient in extent, nor applicable in position, to induce a proper development of passenger traffic. It has consequently struck me that the site in question is admirably adapted for the construction of a first-class hotel, more particularly, as I understand, that the shipbuilding yards belonging to Mr. Clarke, and which I have shown to be absorbed in the area of the proposed enclosure, are no longer in use, and are now for sale. The site affords many advantages, not obtainable elsewhere, and, if properly turned to account, would, I feel assured, prove of great indirect value to the community at large.

Among these advantages may be briefly enumerated the facility and economy with which the space could be reclaimed by the filling and building materials procurable from "Gallows Hill," the very removal of which would create valuable sites for building, and consequently an improved approach to the town to which the hotel would be sufficiently near, while, at the same time, it would retain its convenient proximity to the packet pier and harbour, and have unequalled views over the beautiful bay of St. Aubin, while the proposed viaduct would afford a promenade unsurpassed even by the celebrated Brighton chain pier. To these may be added the possibility of constructing a commodious and convenient bathing establishment on the western side of Elizabeth Castle, free from the influence of the easterly winds.

In finishing an engineering report in this novel manner, I hope it is unnecessary to remark that my only object is, if possible, by any suggestion of mine, to add to the prosperity of an island which has resources within itself sufficient to render it the favourite resort of the travelling public, but for so lengthy a digression I must claim the indulgence of your chamber.

I have the honour to be, Sir,

Your obedient Servant,

GEORGE FOSBERT LYSER, C.E.

To Joshua Le Bailly, Esq.,

President of the Chamber of Commerce of Jersey.

WEST HAM DRAINAGE.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter I wrote you last week on the above subject was not intended for publication, but simply as a private request that you should publish the joint report of Messrs. Lucas and Wilkinson and myself on the West Ham drainage. As, however, it has been published, I presume in error, I think it due to Messrs. Lucas and Wilkinson to tender at once the following explanation. Being connected with certain gentlemen holding property in the district, I introduced Messrs. Lucas and Wilkinson to the committee, as being concerned as engineers in a similar project further up the river Thames; and having consulted with them, we jointly prepared the report and plan to which our three names are appended in full. At the time of writing my former letter, I was under a misapprehension in supposing that Messrs. L. and W. had caused the insertion of the paragraph in question without mentioning my name. As, however, I have since convinced myself that those gentlemen were entirely ignorant as to your notice until after its appearance, I am, of course, extremely anxious to render them justice by removing any unfavourable impression which my hasty letter of last week may tend to induce.

I remain, dear Sir, yours truly,

W. RUSSELL.

Brantwood, December 7, 1867.

BLAST-FURNACES.—The number of blast-furnaces in existence in Great Britain in 1866 was as follows: Scotland, 109; Cleveland, 143; Lancashire and Cumberland, 40; Shropshire, 29; South Yorkshire and Derbyshire, 77; North Staffordshire, 33; Gloucestershire, Wiltshire, and Somersetshire, 15; South Staffordshire, 167; Northamptonshire and Lincolnshire, 16; and North and South Wales and Monmouthshire, 203; total, 892.

TELEGRAPHY IN FRANCE.—The number of despatches sent over the state administered telegraphic lines of France in the first nine months of this year was as follows: interior, 2,052,772; international, 374,098; total, 2,427,479. In the first nine months of 1866, the corresponding totals were: interior, 1,784,763; international, 347,151; total, 2,131,917. Considerable repairs have been carried out this year on the lines from Paris to Bordeaux, Toulouse, Lyons (*via* the Bourbonnais), and Mulhouse.

THE LATE DR. CLARK.

DR. THOMAS CLARK, formerly Professor of Chemistry in Aberdeen University, died at his residence in Partick, near Glasgow, on the 27th ult. Although it is now nearly a fortnight since the event occurred, it is not desirable to permit such a man of mark to pass off this scene of affairs without taking some brief notice of his life and his position as a man of science. Thomas Clark was born in Ayr in the year 1801, and was educated in the academy of that town, having amongst his school contemporaries Lord Cowan—one of the judges of the Court of Session—the late Mr. Weir, editor of the *Daily News*, and Mr. James McClelland, one of the principal accountants in Glasgow, but now retired to London. In the year 1816 he left Ayr for Glasgow, along with the last-named gentleman, and entered the establishment of the well-known firm of Charles Mackintosh and Co., as book-keeper and cashier. His career as a chemist commenced in Mr. Charles Tennant's famous St. Rollox Chemical Works, where he obtained the appointment of chemist on the recommendation of Mr. Mackintosh. The future professor at this time showed a peculiar fondness for studying the practical applications of the principles of his favourite science to the arts and manufactures. In 1826 he was appointed Lecturer on Chemistry in the Glasgow Mechanics' Institution, and began to show not only a ripe acquaintance with the science, as it was then known, but even the possession of large, startling, and original views, which have since been incorporated in chemical treatises.

Being desirous of becoming a teacher of chemistry in a medical school, Mr. Clark entered the medical classes in Glasgow University, and ultimately proceeded to graduate as Doctor of Medicine, and even during his student career at college he introduced into practice a variety of chemical processes which have now acquired an established usage. In the year 1833 the Professorship of Chemistry in Marischal College, Aberdeen, became vacant. It was determined to fill up the vacancy by competitive examination of the candidates, of whom there were three, Dr. Clark being one of them. The four examiners reported in favour of Dr. Clark, and he was elected accordingly. Dr. Clark held this appointment till the union of the two Aberdeen colleges in 1860, when he was superannuated; but he never lectured to his class after the session 1843-4, owing to illness with which he was then attacked.

When Mr. James Beaumont Neilson, of hot-blast celebrity, was compelled to institute legal measures, in 1834, for the protection of his rights as the patentee of the application of the hot blast in iron-smelting furnaces, Mr. Clark became the scientific adviser to the patentee's counsel. One of the earliest papers published in explanation of the philosophy of the hot blast was from the pen of Mr. Clark, and he was even regarded by many persons as the inventor of the process.

What concerns us most in Dr. Clark's scientific career is his connexion with the chemistry of water as a sanitary agent. Everybody who has studied the chemistry of water has heard of Clark's process for softening water rendered hard by the presence of carbonate of lime or other calcareous salts. It was about the year 1840 that he turned his attention to this matter. All ordinary water absorbs carbonic acid from the air, which doubtless assists to give the water that pleasantness of taste which is wanting in distilled water. If the water flow over chalk or limestone, it is enabled, by means of the carbonic acid contained in it, to dissolve the calcareous mineral, which imparts hardness to it. Strangely enough, Dr. Clark bethought him to purify such water by adding to it more impurity; in other words, he proposed to add lime-water, or milk of lime, to the hard water. This lime combines with the carbonic acid, forming carbonate of lime, and thus both the originally dissolved carbonate and the newly formed compound are precipitated from the water. By means of this process the hardness of London water can be reduced from 174 grains of chalk per gallon to 14 grains, thus making it nearly as soft as that of the Dee, at Aberdeen, or that of Loch Katrine, as supplied to the lieges of Glasgow. Were this process applied to the whole water supply of London, it would deposit from this supply 50 tons of chalk daily, and an immense saving in soap and tea would result to the consumers. "Clark's soap test" is as well known as the process just mentioned. This is an ingenious method of estimating with extraordinary precision the amount of lime or hardening matter in solution in any specimen of water; and it is as easy of performance and application as it is precise in its results. For the last twenty years this test has played an important part in the selection of waters for domestic purposes, and both it and the softening process are now in universal use among chemists and sanitary engineers. By means of the soap test, Dr. Clark was enabled to reduce to an exact measure his proposal for softening chalk waters by the addition of lime. His water processes and tests are the things with which Dr. Clark's reputation will ever henceforth be associated. To have become universally known in connexion with the chemistry of water is no mean reputation, and indicates the possession of uncommon mental powers. Those powers belonged to the highest class. Amongst the most marked features of his character sagacity prevailed, and this was frequently shown by the employment of simple and most unlikely means to attain the ends he had in view. His mind was eminently practical.

The most recent incident in connexion with Dr. Clark's life is his appointment as assessor in the University of St. Andrews, to which office he was chosen by Mr. John Stuart Mill when he became Lord Rector of that ancient institution. His great aptitude and experience in university matters were not long at the service of Mr. Mill and the university, owing to his decease within little more than a year of his appointment.

SHEFFIELD.—At Sheffield there is a fair demand for Bessemer steel for the manufacture of railway rails, and in most descriptions of railway materials about an average trade is being done. The armour-plate establishments are well employed; but the other heavy branches of local industry are somewhat languid.

ROWAN AND HORTON'S MARINE BOILER.

WE give, on page 542, engravings of a water-tube marine boiler, constructed on Messrs. Rowan and Horton's patent, such as employed by Messrs. Rowan and Co. for working their compound high-pressure marine engines. Our engravings show the latest modification, adopted after the experience gained in the earlier experiments. The principal point in view in the construction of a water-tube boiler of this kind is the absolute safety from explosion, and the capability of the boiler to carry steam of very high pressure, without any risk of overstraining. The strongest boilers of ordinary construction, introduced on board of ships in this country are the plain cylindrical boilers, such as are made by Messrs. Randolph, Elder and Co. and others, and these boilers carry steam up to 50 lb. pressure per square inch; but this seems to be already the extreme limit beyond which it would be unsafe to go with the large cylindrical shells and their longitudinal stays of different kinds—all liable to be overstrained, if not at the first, still after a short time of working, when the chemical influences of the water and steam have commenced to weaken their original sections. The boiler we have illustrated is constructed for a working pressure of 120 lb. to the square inch; but it is capable of standing a hydraulic test ten times exceeding that pressure without bursting. The small dimensions of each single tube, and the absence of an outer shell of the boiler, make it possible to keep the thickness of metal very moderate in all its parts; so that a boiler of this construction, having a heating surface and evaporative power equal to a tubular marine boiler of the ordinary kind, is not heavier, and takes up no more room, than the latter. The quantity of water contained in the boiler is considerably less than in the common construction, so that the water-tube boiler in its working condition has the advantage of small weight. This boiler is, however, more expensive in first cost, and also more costly in repairs whenever such become necessary; but it appears from the experience gained hitherto that these boilers are less liable to derangement than common marine boilers, and the sum total of all repairs does not exceed, therefore, the expenditure generally required for boiler repairs. The question of first cost is the only point which has to be considered as a set-off against the advantages to be derived from the use of higher pressures of steam, and against the perfect safety from boiler explosions on board of steamers, which the water-tube boiler affords.

Referring to the engravings, it will be seen that the boiler is composed mainly of a series of double rows of vertical tubes, the upper and lower ends of which communicate with rectangular transverse water-spaces. These water-spaces in their turn communicate below with three longitudinal cylindrical barrels, each about 18 in. in diameter, and above with a single similar barrel, carrying two vertical barrels or steam-domes. It will be seen from the longitudinal and transverse sections, Figs. 1 and 2, that the vertical tubes are not all of the same length, the four double rows near the centre extending nearly the full height of the boiler, whilst the other rows are shorter, so as to leave room for the fires beneath them. Plate-iron screens are introduced between the tubes of the four central rows, so that three parallel vertical flues are formed, through which the heated gases pass, as shown by the arrows on the longitudinal section. The horizontal water-spaces, with which the upper and lower ends of the tubes communicate, are connected by vertical water-spaces, and the intervals between these are closed by hollow castings, as shown in the sectional plans, Figs. 4 and 5, and in the enlarged view of a portion of the boiler. There are four firebricks placed just above the level of the three lower barrels, as shown in Figs. 1 and 2, which figures also show the manner in which the fire-doors and ash-pit dampers are fitted. The whole boiler is surrounded by a double casing which envelops the steam-domes, the casing being so formed that the domes are exposed to the current of heated gases on their way to the chimney.

COMMUNICATION BETWEEN PASSENGERS AND GUARD.

TO THE EDITOR OF ENGINEERING.

SIR,—I send you my proposal for effecting this object at a comparative (to some projects) small cost.

It is this: on the roof of each carriage I would place a box containing proper apparatus for compressed air, and attached thereto a whistle, having separate rods, levers, and pulls to each compartment, constructed so that the reversed lever on the roof of the carriage would show in which compartment the alarm was raised.

This plan, in my opinion, would prove both efficient and cheap, as it would require no attendance or cleaning, and could easily be adapted to the present carriages at a small cost.

Would you please grant this a place in your excellent paper, if you think it serviceable?

I am, dear Sir, yours very truly,

F. J. H.

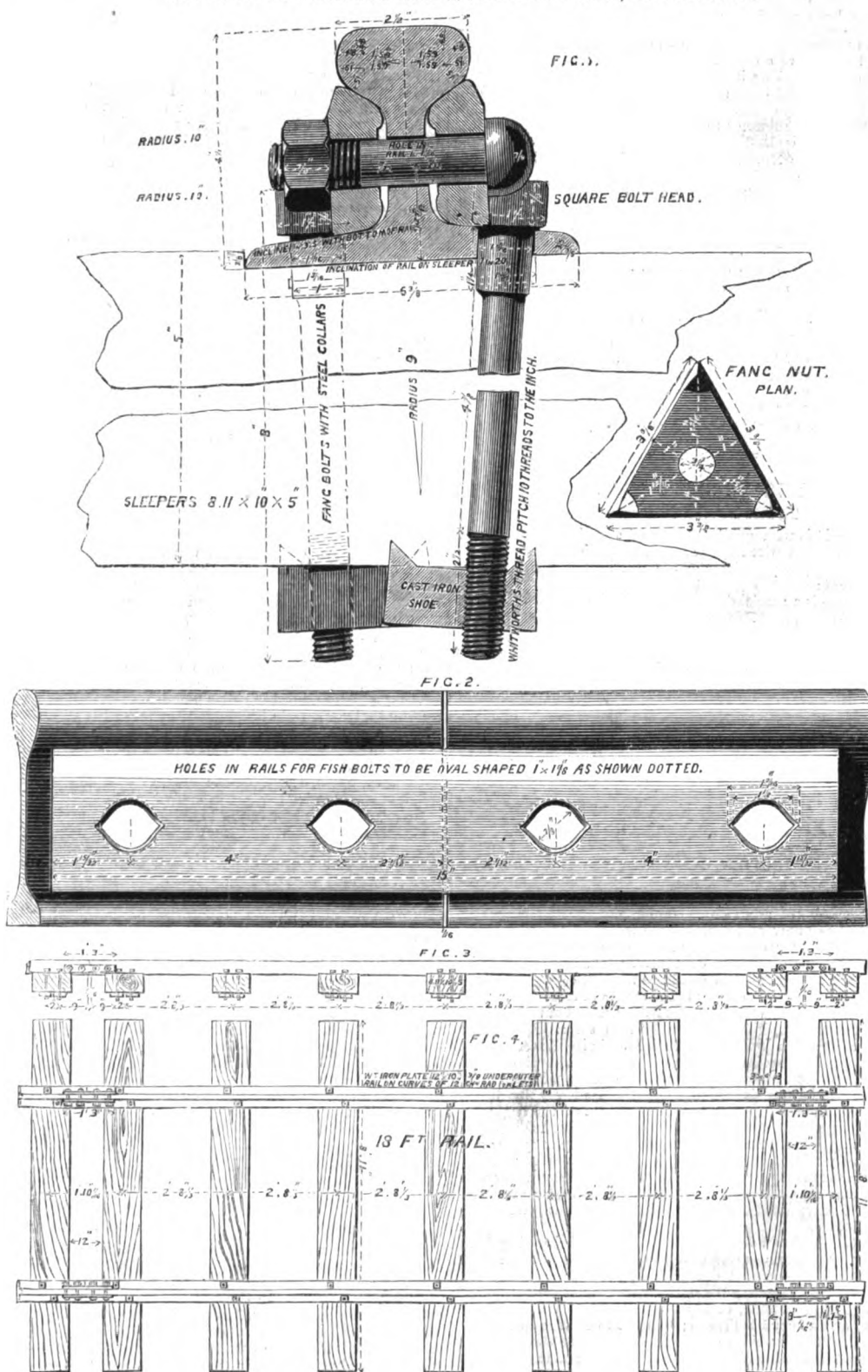
Warrington, December 11, 1867.

[We publish our correspondent's letter; but we must at the same time state that his plan is not new, and that it is of no practical value. Under but very few circumstances would the whistles he proposes to use be heard by the guard, and, in fact, no sound-signals can be depended upon for effecting a communication between the passengers and guard of a train in motion.—ED. E.]

CHILE.—The Chilean Government has just signed a contract with the English Pacific Steam Company for the establishment of a line of steamers between Valparaiso and England, *via* the Straits of Magellan and Montevideo. The steamers to be devoted to the conveyance of passengers and goods on the new line will be from 2000 to 3000 tons burthen, and the subvention paid by the Chilean Government will be 20,000*l.* per annum. The contract is for ten years. The new service is to be established within a year from the signature of the contract. The company further undertakes to continue the working of a line of steamers established on the southern coast of the Pacific, as far as Puerto Monte, on the same conditions as at present.

PERMANENT WAY OF THE METROPOLITAN DISTRICT RAILWAY.

MR. JOHN FOWLER AND MR. T. MARR JOHNSON, ENGINEERS.



THE annexed engravings, showing the permanent way adopted for the Metropolitan District Railway and other portions of the metropolitan system, will be of interest to many of our readers, as illustrations of recent practice. The permanent way on the metropolitan lines, is subjected to traffic of the heaviest kind, and from the frequent intervals at which the trains are run, and the few hours in each day during which the traffic is discontinued, it is of the greatest importance to adopt such a system of permanent-way construction as may involve the least amount of repairs. The rails of which we gave a full-size section on page 501 of our last number but one are of steel, and are being rolled at Dowlais. In our illustrations, Figs. 1 and 2 are respectively a section and side elevation of the rail and fish-plates, and Figs. 3 and 4 represent a short length of the permanent way, drawn to a smaller scale. As all the dimensions and particulars are marked on the engravings, no further description of them will be necessary.

ENGLISH RAILWAY CARS.—A correspondent writes us a most vigorous and rather lengthy protest against the adoption of the English style of railway car, a few of which can be found on some of our roads. The objections to these cars are want of proper ventilation in warm weather, and lack of heating facilities in cold weather. There can be no objection

to any one's riding in these cars if they so desire, if they are willing to put up with the discomforts and pay the extra price demanded. Exclusiveness costs something in the shape of comfort and money. We coincide with our correspondent's view so far as the comfort, or rather want of it, is concerned; but it is not an impossibility to ventilate the different compartments of the car, and not impossible to warm them; but the more room and the means for these things will cost more money, and passengers will have to pay a corresponding price. Space and weight have to be paid for in passenger cars. The common 60-seat American car costs from \$4000 to \$5000 each, while the English style of car on the Old Colony road costs about \$13,500. There is a wide difference, too, in the weight, in favour of the American car. The interest on the greater cost, and the hauling of the extra weight of the English car, will have to be paid for by those who use them. So far as we can learn, the English cars have not proved a profitable investment, and we think there is no great danger of their being widely adopted. The financial element settles the question, and though some few of the railways may have a class of passenger traffic that is willing to pay for all the comforts of home, including parlours, sleeping-rooms, &c., while travelling, yet few companies can afford to build and keep such cars for this exceptional class of passengers.—*American Railway Times.*

HULL SOUTH BRIDGE.

In our two-page engraving, and that on the opposite page, we illustrate the swing bridge recently erected over the river Hull, near its junction with the river Humber, by which the parish of Holy Trinity, in the borough of Kingston-upon-Hull, has been placed in direct communication with "the citadel" and the extra-parochial place called "the garrison side." In our engravings, Figs. 1 and 2 are an elevation and plan of the bridge, Fig. 3 is a cross section through turntable, Figs. 4 and 5 are transverse sections, Fig. 6 is an elevation of the hand-railing, Fig. 7 is a plan of the live ring of the turntable, Fig. 8 is a general plan of the bridge, Figs. 9 and 10 show the locking gear, Fig. 11 is a plan of the lower roller-frame, Fig. 12 is a section of one cylinder, and Figs. 13, 14, and 15 show the turning gear.

This bridge consists of two parts, namely, a movable part on the eastern or citadel side, which, when open, gives a clear waterway of 100 ft.; and a fixed part on the western side, with a clear span of 40 ft.

Unlike the bridge at Newhaven, recently illustrated in this journal, the swinging portion of this bridge is made of two arms of unequal lengths, the one being about 122 ft. long, and the other 47 ft. long, properly loaded, so as to balance the long arm.

The eastern support of the bridge is a brick pier resting upon piles driven to a depth of about 60 ft. below high water of spring tides; the piles are made of whole timbers 12 in. square, with their heads bedded into a layer of concrete 3 ft. thick, and bound together with sills of the same scantling, and covered with 6 in. planking, the entire area occupied by this piling closed in by sheet piling of half timbers. The pier is built up solid with brickwork set in Portland cement, the river face of it having a batter of $1\frac{1}{2}$ in. to the foot.

The coping of the river wall, and the stone upon which the turntable is bedded, consists of granite ashlar 2 ft. thick and from 5 to 6 ft. long.

At a distance from the centre of the turntable equal to the radius of the short arm of the bridge, a circular dwarf wall, resting upon a bed of concrete, and crowned with a granite coping at the level of the roadway of the bridge, sets off the space over which this end travels when the bridge is swung round; and the space intervening between the pier and the dwarf wall is covered with Brough stone paving, bedded upon a layer of concrete 12 in. thick.

At its western extremity, when closed, the swing bridge rests upon two cast-iron caissons filled with cement concrete. These caissons, which are sunk to a depth of about 60 ft. below high water of spring tides, are 9 ft. in diameter throughout the greater portion of the length sunk into the ground. The upper portions are reduced to a diameter of 6 ft., and terminate at the top with neatly moulded caps.

The fixed portion of the bridge rests upon these caissons at its eastern extremity, and at the west end it rests upon a brick abutment 7 ft. thick, carried by piles and crowned with a granite coping like the east pier. This abutment is built in a line with the west river wall, of which it forms part.

The main girders of the swing bridge are hog-backed, single-web girders 11 ft. 9 in. deep over all in the plane of the centre of the turntable, tapering down to 4 ft. 6 in. at the end of the long arm, and to about 8 ft. 9 in. at the end of the short arm. These girders have been constructed on the assumption that they are subjected to the greatest fatigue when open, and in consequence both the webs and the flanges are gradually increased from the ends to the point where they take their bearing upon the upper tram of the turntable. At this point the webs are $\frac{1}{2}$ in. thick, decreasing to $\frac{3}{8}$ in. at the end of the short arm, and to $\frac{1}{4}$ in. at the end of the long arm. The top and bottom flanges are alike throughout, and are 2 ft. 3 in. wide, made of six $\frac{3}{8}$ in. plates over the turntable, reduced to two at the end of the short arm, and to one at the end of the long arm. Besides these there is a continuous cover-plate $\frac{1}{2}$ in. thick throughout the length of the girders, being the layer of plates next the angle irons, but are of course not to be reckoned as forming part of the effective sectional area of the flanges. The angle irons are 5 in. $\times$ 5 in. $\times$ $\frac{3}{4}$ in., and the joints of the web plates are covered by T irons 6 in. $\times$ 3 in. $\times$ $\frac{1}{2}$ in., excepting over the turntable at the end of the short arm, which carries a heavy dead weight of kentledge, and at several points in the long-arm, where the web is stiffened by means of $\frac{3}{8}$ in. and $\frac{1}{2}$ in. gusset plates rivetted to the web and to the flanges by means of $3\frac{1}{2}$ in. angle irons.

The distance from centre to centre of the main girders is 22 ft. 3 in.; and the cross girders, which occur about every 4 ft., project about 7 ft. beyond these. There is thus a clear roadway of 20 ft. for the heavy traffic between the main girders, and two side walks of a clear width of 5 ft. for passenger traffic, fenced by a railing 4 ft. high, the ends of the cross girders and of the roadway planking being hidden by a neat cast-iron coping throughout the length of the bridge. The cross girders are 15 in. deep in the centre of the roadway and 12 in. under the main girders, so made as to give the roadway a camber of 3 in. for the purpose of throwing off the rain-water towards the sides of the bridge. The overhanging portion of the cross girders tapers off from 12 in. to 7 in.; the web-plates are $\frac{1}{2}$ in. thick, and the top and bottom flanges consist of a couple of $3\frac{1}{2}$ in. angle irons $\frac{1}{2}$ in. thick.

The roadway consists of a lower layer of 4 in. creosoted Memel planking laid longitudinally, and of an upper layer of 2 in. Baltic oak laid transversely. Two horse-tracks are laid upon the central roadway, the planking being covered by bars of $\frac{1}{2}$ in. flat iron over a space of about 22 in. in width throughout the length of the bridge, at suitable distances for the pitch of the wheels of vehicles in general use, one of them being specially prepared for railway trucks.

The length of the overhanging portion of the long arm of the bridge is about 110 ft.; the depth of the girders at the point where they abut upon the turntable is 11 ft. 3 in. from centre to centre of the flanges, and the effective transverse section of the plates in the top flange is $78\frac{1}{2}$ square inches, making $157\frac{1}{2}$ square inches for the two girders; this does not include any portion of the angle-irons, because, with six thicknesses of $\frac{3}{8}$ in. plates and an $\frac{1}{2}$ in. cover-plate besides, the girder would be practically broken before the angle-iron could offer any considerable resistance to the bending strain. On the other hand, the load on this portion of the bridge, when swung open, may very ap-

proximately be taken as follows, the whole reduced to a leverage of 55 ft.:

	tons.
Roadway planking	53
Cross girder	28½
Main girders	73½
Railings, horse-tracks, cornices, curbs ...	25
Total	180

With these data, the strain per square inch upon the flanges is easily found by means of the following equation:

$$180t \times 55 \text{ ft.} = x \times 157.5 \text{ sq. in.} \times 11.25 \text{ ft.},$$

$$180 \times 55$$

$$\text{whence } x = \frac{157.5 \times 11.25}{180 \times 55} = 5\frac{1}{2} \text{ tons,}$$

or about one quarter the breaking strain of good iron.

It will now be interesting to see what load the bridge is able to carry when closed, with the same strain upon the flanges at the point of greatest fatigue:—To this effect, remembering that the long arm is carefully balanced, we may in the first place assume that there will be a point of contrary flexure at a distance of about 30 ft. from the extreme point of support over the turntable, thus leaving a length of 80 ft. to be dealt with as an ordinary girder bridge supported freely at both ends. The depth of the girders at a distance of 40 ft. from the ends is about 7 ft. 2 in., and the collective transverse area of the bottom flanges of the two girders is 78½ square inches; with these data, the load equally distributed which the bridge is able to carry when closed will be found as follows:

$$W = 2 \times \frac{4 \times 5\frac{1}{2} \times 78\frac{1}{2} \text{ sq. in.} \times 7 \text{ ft. 2 in.}}{80 \text{ ft.}} = 312 \text{ tons.}$$

Deducting from this amount the weight of the structure itself which, for this portion, is very approximately as follows:

	tons.
Roadway planking	39
Cross girders	21
Main girders	63*
Horse tracks, curbs, cornices, railings ...	19
Total	142

We find that the carrying capacity of the weakest part of the bridge when closed is 170 tons, or 1.4 cwt. per square foot, which is more than it ever will be called upon to carry.

The turntable, whose mean diameter is 30 ft., consists of a lower cast-iron tramway bolted to the granite coping of the brick pier, and of an upper cast-iron tramway to which the girders are bolted, and upon which they take a bearing 24 ft. long; the faces of the tramways are turned to a true cone, having its apex upon the axis of the turntable, and between them is inserted a wrought-iron live ring fitted with 30 wrought-iron rollers 2 ft. diameter and 12 in. broad, turned to fit exactly the faces of the tramways, and keyed upon wrought-iron radial spindles 3 in. in diameter, which take their bearing in brass bushes fitted into both the outer circular frames and the centre of the live ring. This centre is a solid wrought-iron wheel 8 ft. 6 in. diameter, with radial arms or spokes similar in every respect to a wrought-iron locomotive wheel; its central boss is bushed with brass and bored to fit truly a projection on the nave of the bottom tram.

In reference to the detail of the construction of the live ring, we have no doubt our readers will agree with us, upon careful examination, that it is preferable to have fixed roller spindles, made to bind the outer frames rigidly with the centre, and to have the rollers loose upon the spindles; this mode of construction entails at once less difficulty and expense in fitting, and renders the structure more rigid and less likely to be strained out of shape during the process of opening and shutting the bridge.

The turning gear originally provided consisted of a vertical or capstan shaft, 4 in. diameter, resting in a footstep, and held at the top by a cast-iron stand at a distance of about 42 ft. from the centre of the turntable; upon this was keyed a pinion 12 in. in diameter, which geared into a spur-wheel 4 ft. in diameter, these working, of course, in a horizontal plane; upon the spindle of the spur-wheel, which had its bearings in a cast-iron box bolted to the masonry of the pier, a chain drum, 2 ft. 8 in. in diameter, fitted with wrought-iron cogs, was keyed. A series of segmental castings, forming a segmental chain pulley over about two-thirds the circumference of the upper tram, were bolted thereto, and an open link chain, passing over the small chain-wheel previously mentioned, was fixed to the two ends of the segmental chain pulley, and drawn up taut by means of strong screws and nuts. By working round the capstan shaft, it would follow, as a matter of course, that the bridge should swing round.

This process, however, was found exceedingly tedious and, worse, slow, and consequently an opening gear worked by hydraulic machinery was subsequently applied. This portion of the subject will be illustrated and described in a subsequent number.

Locking apparatus fixed upon the top of the caissons for the purpose of bringing the end of the long arm of the bridge to a solid bearing when it is closed. These consist of cast-iron wedge blocks fitted to the underside of the ends of the main girders, and of cast-iron foundation-plates bolted to the bearing-stones in the top of the caissons. When the bridge is to be locked or unlocked a cast-iron wedge, into which a brass nut is fitted, is either forced between or pushed away from the wedge block, and the foundation-plate by means of a strong wrought-iron square-threaded screw carried by pedestals fixed to the foundation-plate; this screw, which terminates in the shape of an ordinary shaft, projects some 4 ft. underneath the fixed part of the bridge, and is worked from the top of the bridge through a vertical shaft driving a horizontal worm shaft by means of a pair of small bevel wheels; the worm keyed upon this shaft gears into a worm-wheel keyed upon the end of the screw-shaft, which, as it revolves either to the right or to the left, communicates a backward or forward motion to the wedge.

The roadway of the fixed portion of the bridge is similar in

* This weight is slightly increased to make compensation for the increase of weight of the girders as they near the turntable.

every respect to the swinging portion; the cross girders are identical in shape and scantling with those of the swing bridge; but the main girders are made of an even depth of 4 ft. 6 in. throughout; their flanges are made of a single layer of plates 15 in. wide, and vary in thickness from ¾ in. in the centre to ½ in. at the ends; the angle irons are 3½ in. × 3½ in. × ½ in., and the rivets ¾ in. diameter × 3½ in. pitch.

The collective sectional area of the bottom flanges of the two main girders, taking into account the horizontal member of the angle iron, is 25.13 square inches, and the clear span being 40 ft., the load equally distributed, which they are able to carry when the flanges are subjected to the same strain as those of the other main girders, is

$$W = 2 \times \frac{4 \times 5.5 \times 25.13 \text{ sq. in.} \times 4.5 \text{ ft.}}{40 \text{ ft.}} = 124.38 \text{ tons.}$$

Deducting from this the permanent load, which is made up as follows:

	tons.
Roadway planking	19½
Cross girders	10½
Main girders	9½
Railings, cornices, horse tracks, curbs ...	9
Total	48

There remain for the carrying capacity of this part of the bridge 76.38 tons, or 1.27 cwt. per square foot, which comes up very closely to that of the other portion of the bridge.

The design of this bridge emanates from the office of Mr. Hawkshaw, and the whole of the work was executed by Mr. H. Grissell, of the Regent's Canal Ironworks.

ENGINEERING ECONOMY.

TO THE EDITOR OF ENGINEERING.

SIR,—It is with great feelings of surprise and of sincere sorrow that I notice in your article on the Glasgow Locomotive Works, in your issue of the 6th instant, the following statement:

"There is a special drawing-office in the Glasgow Locomotive Works, apart from the rest of the offices, and this is occupied by three women. . . . Mr. Dubs states that they have been extremely quick in acquiring the necessary skill for correct tracing; that they work with superior accuracy and industry as compared with the well-known class of apprentices and other individuals comprised under the technical denomination of 'youngsters'; and last, but not least, that they have no ambition to make designs of their own."

While the question of technical education has been so prominently brought before the professional public in the columns of your journal, and before the general public elsewhere, the facts published in the above statement are made known just at a very seasonable time to illustrate the downward tendency of some recent innovations in engineering economy. If it be true, as Mr. Dubs informs us, that these women work with superior accuracy than ordinary engineering apprentices, or "youngsters," this fact only further proves the necessity of establishing proper engineering classes at some of our universities, where the whole group of sciences which should form part of the knowledge of the engineer are taught, including that of descriptive geometry, which, in its more elementary stages, constitutes the science of geometrical projection, and which study is one means of creating a liking for drawing in him who pursues it, on account of the interesting problems which it teaches him to solve. Descriptive geometry, which is not a science difficult in itself, is eminently the one which requires the close and patient attention of the mind, that it may trace for itself a correct picture of the subject under consideration represented merely by lines; likewise, and for the same reason, is the art of the engineering draughtsman one of close attention, whether in originally designing, or in remodelling, or even in merely copying; and unless the mind has received some previous training at that age when it is most pliable, it will never be thoroughly well suited for the duties of the draughtsman, excepting, of course, in those exceptional cases where there is a natural bias in that direction.

Those who know the history of English engineering firms will, I am certain, agree with me that those of them have had the best appointed drawing-offices which, besides a fair sprinkling of Scotch, have employed the greatest number of foreign draughtsmen, chiefly Germans, some Swedes, some Swiss, and a very few French; this not to be sure on account of the natural disability of English youths for drawing, but on account of their dislike to the close work of the drawing-office.

It is almost needless to say that I make no reference here to inventive mechanical genius, since it is a well-known fact that many mechanical contrivances were originated by men utterly incapable to represent their ideas upon paper.

In the absence, however, of this preliminary training, to employ young men in tracing correct drawings is a very good means to teach them, by the mere force of habit, the general principles of geometrical projection to the extent to which they are required for the ordinary routine of the drawing-office, and on that account, therefore, is Mr. Dubs's practice to be condemned, since it robs his ordinary apprentices of one of the natural means at command in a workshop to learn their business thoroughly.

On the Continent, and especially here in France, where, as a rule, more drawing is done for an equal amount of work than in England, and where in a number of shops the practice has prevailed, as far back as my recollections in the profession carry me, of making even duplicate tracings of every drawing, no attempt has ever been made of employing women to do this work, which has always been considered as a legitimate means of initiating young men from the schools into the practice of the workshops, and thus to prepare them for more responsible and more remunerative employment. Some firms even have discountenanced the practice of getting these tracings done piecemeal, which practice I believe has

never been persistently carried out by any firm but Cail and Co.

What, however, am I to say about that other reason advanced by Mr. Dubs for thus employing women, namely, "that they have no ambition of making designs of their own"? Does this not verify, in a most emphatic manner, the statement which I recently made in a letter to you, that there seems to be a jealous feeling on the part of some employers lest their young men should know too much? I venture, however, to say that this statement is a true picture of the man as an employer, and I would caution the fathers of ambitious youths with a liking for mechanics not to entrust them into the hands of Mr. Dubs for development into practical use.

But let us see how far Mr. Dubs is justified in entertaining feelings of jealousy like these towards the youth whom he may employ or apprentice. Why, Sir, if my memory serves me correctly, Mr. Dubs is a German by birth, and enjoyed in his younger days the privilege of being employed by the house of Sharp, Roberts, and Co., and giving him all due credit for his engineering qualifications, he undoubtedly owes them in a great measure to his early practice, either under Mr. Roberts himself or under Mr. Beyer; and such is the hospitality which he has enjoyed in England, that he is able to make a deadly competition to his early employers and others, the fathers of engineering industry, in return for which he takes care that his young men shall have no scope for their ambition to make designs of their own, and employs women to do their work.

So much for the educational aspect of this matter.

The economic aspect of it is very intelligible, and when Mr. Dubs had stated that "these tracings were done at a very economical rate," there was no need for any further reasons to explain his motives; in fact, Mr. Dubs's statement reminds me very much of the story of the German commander of a fortress, who, on being requested before a court-martial to justify his conduct in surrendering the same, assigned *nineteen* reasons, one of which was that he had no powder left to carry on the defence. But to return to the economic aspect of the subject, how different is this from Mr. Beyer's practice, whose dictum was, when I had personal dealings with him, and I presume remains, that he wants *men* to do his work; Mr. Dubs wants *women*. Yet at the same time the *men*, and especially the *draughtsmen* (mostly bachelors), have the greatest difficulty in the world to get their underlinen made, washed, and amended, and their buttons sewed on.

What a picture, however, rises before my eyes, when, upon reading that "Mr. Dubs has sagaciously taken the precaution of dividing the drawing-office of the female employees into small compartments by thin partition-walls reaching up to the ceiling, so that the girls cannot see each other," when upon reading this, I consider the humane and philanthropic aspect of the question!

Every one knows how trying to the chest is the work of the draughtsman, and it is well known that many young men have gone into consumption through stooping over or leaning on their drawing-board; how much more trying, then, must it be to the more delicate nature of a woman, especially if she should happen to be somewhat full-breasted? Yet to reduce to a minimum the inducement to occasional relief from over-continued exertion of a purely physical kind, Mr. Dubs "very sagaciously" puts these poor creatures under a kind of restraint similar to the system of cellular confinement which has long since been condemned by moralists and philanthropists even in the case of felons and criminals. To my thinking, it required a refinement of cruelty to inaugurate a system of employment under such restraint, and I think Mr. Dubs would but earn a well-deserved punishment if the ladies of Glasgow turned their backs upon him when he attempts to speak to them, and if the working women of Glasgow pelted him with all their catalogue of injurious epithets when he appears amongst them.

I remain, Sir,

Yours very truly,

December 10, 1867.

J. J. BIECKEL.

COMPOUND RAILS.

TO THE EDITOR OF ENGINEERING.

SIR,—While a new compound rail is about to be tried, allow me to remind your readers that, in your number of 1st February, 1867, you published in *extenso* my paper on iron permanent-way as used in Germany.

The rail designed by Mr. Ashcroft is in principle the same as the original Brunswick rail of 1864, with the modification of the grooved web of the head rail, and corresponding web in the angle beams, which was patented by me in September, 1866. Of this system the Hoerder Works have just supplied a length of thirteen miles to the old pioneer of iron permanent-way improvements, the Brunswick Railway, in this instance, as in all preceding very successful trials, wooden sleepers being entirely dispensed with, and the angle bars 5×5 Prussian inches resting directly on the ballast.

Theorists have long enough described such a construction as necessarily forming a hard road, but practice has proved the reverse; and the principal Prussian railways, the Rhenish, Cologne-Minden, &c., are all gradually adopting the longitudinal iron way in its simplest form.

With the present price of iron and steel, its first construction is not dearer than the old system, under all circumstances the cost of keeping the line in thorough efficiency much cheaper, nay almost nominal; and thus it seems inexplicable that in countries like India wooden sleepers should still be used, when in reality there is nothing left to advance in their favour.

I am, Sir,

Yours respectfully,

23, Abchurch-lane, E.C.,

F. H. ROCHUSSEN.

Dec. 9, 1867.

NITRO-GLYCERINE.—There has been a violent explosion of nitro-glycerine at a quarry at Bergen, New Jersey, U.S. Nine men were blown to pieces, and several others wounded.

INSTITUTION OF CIVIL ENGINEERS.

JOHN FOWLER, ESQ., *President, in the Chair.*
December 3, 1867.

THE first paper read was, "Description of the Victoria Bridge, on the line of the Victoria Station and Pimlico Railway," by Mr. W. Wilson, M. Inst. C.E.

It was stated that this bridge crossed the river Thames about 150 yards to the eastward of the Chelsea suspension bridge, at a point where the width of the waterway between the embankment walls was 740 ft. It consisted of four segmental wrought-iron arches, each having a span of 175 ft. at the springing, with a rise of 17 ft. 6 in., and a clear headway of 22 ft. above Trinity high-water level. At the northern end there was a land opening of 70 ft. span crossing the Grosvenor-road, and on the southern shore there was a corresponding opening of 65 ft. span, crossing the wharves of the Brighton Railway Company.

In the first place, the gravel was dredged out of the bed of the river, down to the clay substratum, for a breadth of 100 ft., and extending across the entire width of the water. Cofferdams, constructed of two rows of whole timbers, waled and strutted in the usual manner, were then driven 4 ft. below the level of the intended foundation. When the enclosed area was cleared of water, the clay was excavated to a depth of 40 ft. below Trinity high-water level. The space to be occupied by the foundations was next surrounded by permanent sheet piles driven to a depth of 8 ft. below the lowest foundation level. Within this sheeting a bed of cement concrete, 4 ft. in thickness, was formed, and on that the masonry of the piers was commenced, the concrete being afterwards carried up to the top of the sheet piles round the entire circumference of the piers. From the footings up to the level of 4 ft. below low water the piers were built entirely of brickwork in lias mortar; thence to high-water level they were faced with rock-faced Portland roach-stone, with one through course halfway up. The core, or backing, was composed of pavior-bricks, set in lias mortar, and the cutwaters, caps, springers, and other masonry above high water were of tool-dressed Bramley Fall stone. The width of the piers at the springing line was 12 ft. 4 in., and from the extrados of the arch to the level of the cornice the width was 10 ft.

The superstructure of each of the four principal openings consisted of six wrought-iron arched girders, springing from cast-iron bed-plates fixed to the masonry. Horizontal girders, resting on the piers and on the abutments, and rivetted to the arch near the crown, formed the longitudinal bearers for the roadway. The spandril, or intermediate spaces between the arched ribs and the horizontal girders, were filled in with a wrought-iron framework radiating from the arch; and between the horizontal bearers cross girders, for carrying the roadway, were fixed at distances averaging about 3 ft. apart.

A detailed description was then given of the ironwork of one of the principal spans, that of the others being precisely similar: from this it appeared that all the six ribs, of which each arch was composed, were alike in construction, but varied in sectional area: they were I shaped, the top and bottom flanges and the central web being composed of flat plates, connected together longitudinally by angle-irons, and vertically by T-iron stiffening pieces. The two middle ribs, which might each have to carry half the load on one line of rails, had each a sectional area of 80 in.; the ribs intermediate between these and the outer ribs had each a sectional area of 71.2 in., while the sectional area of each of the face ribs was 53.4 in. The horizontal girders were continuous over the entire length of the four principal openings, and in the centre of each pier a stiff expansion-joint was provided for the purpose of equalising the strains under different temperatures. The joints were made and the bolts screwed up at a mean temperature of 60°; and the girders, which rested on bed-plates on each side of the open joint, were perfectly free to expand or contract, the continuity of strain being always preserved by the elasticity of circular vulcanised india-rubber washers, two such washers being provided to each bolt.

A segmental cast-iron shoe was bolted to the end of each rib, and rested in a corresponding concave bearer, working loose in a cast-iron frame fixed to the masonry, and provided with wrought-steel keys and cotters, for adjusting the arched rib in position. By this arrangement the whole compressive strain was distributed over the entire sectional area of the arch, whatever the state of the temperature. Each pair of ribs and horizontal bearers were connected together, so as to form, as it were, the two into one box-girder. In addition, there was a complete system of vertical and transverse bracing and strutting to both the girders and the spandril filling.

The total cost of the bridge, including the land arches and abutments, was about 84,000l. The superficial area of the roadway, between the parapets, being 81,690 ft., the cost per square foot was 2l. 13s.; while the total length being 930 ft., the cost per lineal foot was 45l. 3s. Only twelve months were occupied in the erection of this important structure.

The works were designed by Mr. Fowler (President Inst. C.E.), and were carried out under his supervision by the author. Mr. John Kelk, M.P. (Assoc. Inst. C.E.) was the contractor, and the ironwork was sublet to Messrs. Bray and Waddington; the wrought-iron-work was supplied by the Monk-bridge Iron Company, and the cross girders and angle-irons by the Butterley Company.

After the arches were erected and the supports were removed, the ironwork was subjected to severe tests, by loading each arch with a moving weight of 350 tons, placed on the two lines of way, being equal to a load of 1 ton per lineal foot on each pair of rails. Commencing at the north end, the load was placed on the 70-ft. openings, extending over the abutment up to the centre of the first arch; the deflection of the 70-ft. girders was 0.48 of an inch in the centre, the greatest deflection of the arched rib was 0.58 of an inch at a point 60 ft. from the abutment, and 0.38 of an inch at the crown, and the horizontal girder showed a deflection of 0.72 of an inch at 60 ft. from the abutment; while a rise was produced in the adjoining arch of 0.12 of an inch at the crown, the third and fourth arches showing no movement. The load was next moved over the entire span of the first arch, when there was a deflection of 0.71 of an inch at the crown, and of 0.56 of an inch at points 35 ft. on each side of the centre; at the same time the deflection

of the horizontal girder was regular throughout its entire length, commencing with 0 over the piers and increasing gradually to 0.71 of an inch at the centre; the adjoining arch, which was unloaded, showed a rise in the centre of 0.16 of an inch, and at 30 ft. nearer the load of 0.17 of an inch; the horizontal girder also rose 0.24 of an inch midway between the pier and the centre of the arch, but no change was perceptible in the third and fourth arches. The load was then passed on to the centre of the first pier and extended from crown to crown of the first and second arches, when a depression of 0.41 of an inch was produced at the crown of each arch, and of 0.36 of an inch and 0.24 of an inch in the horizontal girders midway between the piers and the centres of the arches. The second arch was then subjected to the whole strain, and subsequently the third arch. The loads were then removed, and a train of engines, weighing 1 ton per lineal foot and 175 ft. in length, was run at full speed over one line of way; this produced deflections of 0.40, 0.48, 0.45 and 0.45 of an inch in the four arches respectively. After the experiments were completed, the permanent set was ascertained to amount only to 0.10 of an inch in the first and second arches, and to 0.12 of an inch in the third and fourth arches. In conclusion it was remarked that every part of the ironwork took its fair share of duty, and that the extreme strains, produced by the most unfavourable combination of circumstances, in no case exceeded 44 tons per inch of section.

The second paper read was, "On New Railways at Battersea, with the widening of the Victoria Bridge, and Approaches to the Victoria Station," by Mr. C. D. Fox, M. Inst. C.E.

The system of railways, designed by Sir Charles Fox, M. Inst. C.E., in the year 1862, for the purpose of improving the access to the Victoria Station, by providing additional lines, and avoiding the sharp curves and steep gradients of the then existing railways, comprised:—the widening of the Victoria Station and Pimlico Railway, and of the Victoria Bridge over the Thames; the high-level line from the south end of the Victoria Bridge to near Clapham Junction, with a branch to the Wandsworth-road; the diversion and raising of the West End and Crystal Palace and West-London Extension Railways, the Longhedge Junction, and the two low-level lines from the Victoria Bridge to Stewart's-lane; and the connecting link between the London and South-Western and the London, Chatham and Dover systems at Clapham Junction.

In widening the Victoria Station and Pimlico Railway, the chief work was the removal of the retaining wall from one side of the existing line—an operation of some difficulty, from the excellent character of the concrete and brickwork originally used, as on account of trains so frequently passing, blasting could not be employed. A girder bridge was successfully substituted in place of an arch over the line, by cutting away a narrow strip of the arch, and inserting one girder at a time.

It was originally intended to construct an independent bridge over the river Thames, to carry three lines of way for the London, Chatham, and Dover-traffic; but it having been determined to add, at the same time, a third line for the London, Brighton and South-Coast Railway Company, it became necessary to make arrangements for joining up the new work with the Victoria Bridge. The new bridge, in common with the original one, consisted of four river spans, of 175 ft. each, having arched ribs, with a rise of 17 ft. 6 in., and of two land openings, carried by plate girders, one of 70 ft., the other of 65 ft. span. Its width, from the outside of the original bridge to the parapet, was 100 ft., giving, with the old work, one structure 132 ft. 6 in. wide between the parapets. The total length of the piers and abutments just below the springing was 158 ft. The excavations of the abutments were got out by means of coffer-dams, the enclosed area being afterwards covered with cement concrete, 3 ft. in thickness, then with brickwork in cement, also 3 ft. in thickness, surmounted by outside and cross walls of brick in cement, the pockets being filled with lime concrete. In consequence of the proximity of the original bridge, it was impossible to drive the coffer-dams so as to include the whole of the work, and a portion of the face was therefore carried on strong cast-iron girders, put in at low-water mark, resting at one end on the old and at the other on the new work. By the use of cement, and the care taken to keep the joints thin, the abutments, though bonded up with the old work, had not shown the least sign of movement. The foundations of each pier were carried down by means of four cast-iron cylinders, each 21 ft. internal diameter; temporary wrought-iron cylinders, 19 ft. in diameter, being used for the top. About 100 tons of kentledge were used in sinking them; this was laid upon stages slung within the cylinders, as being less liable to tilt them than when placed outside, and more easily thrown off when the requisite depth was reached. The cylinders were all sunk to an average depth of 45 ft. below Trinity high-water mark, of which 13 ft. were into the London clay, the total time occupied in sinking being on an average eight days. The cylinders were filled with cement concrete to a depth of 12 ft., and then with brick in cement up to low-water mark. The brickwork was then tested, and afterwards the masonry was commenced. The stone-work face, between the cylinders and forming the connexion between the old and the new work, was carried on strong cast-iron framework.

The superstructure of each of the river spans was precisely the same, and consisted of eight main ribs, with provision for a ninth. Of these, the rib nearest the existing bridge was only one-half the strength of the others, which were each calculated to carry a single line of way. These arched ribs were of wrought iron, 3 ft. 4 in. deep, and the flanges were 18 in. wide; but for 38 ft. in the centre of the span they merged into one with the horizontal girders, thus giving a total depth at the centre of 4 ft. 6 in. The flanges of the ribs gradually diminished from a thickness of 3 in. at the centre to 1½ in. at the springing, the webs being of plates ¾ in. thick throughout. The sectional area of the rib at the centre was 166.9 square inches, or, deducting rivets, 142.5 square inches; the sectional area of the rib at the centre was 102.4 and 86.5 square inches respectively. The horizontal girder was 4 ft. 6 in. deep, with flanges 18 in. wide, and was continuous throughout, the whole bridge being rivetted up for a length of 913 ft. It was firmly connected with the cast-iron standards at the piers and at the abutments in order to obtain the full advantage of continuity for the land spans, and was anchored by a plate running from the top flange down to the cast-iron skew back. The main ribs were braced by

transverse girders and by vertical diagonal bracing; the four middle ribs being further crossbraced horizontally.

The calculations of the strains, from which the superstructure was designed, led the author to the conclusion that, whilst cast iron was the best material for arched bridges of single spans, similar bridges of several spans, having piers whose perfect stability under horizontal stress could not be relied on, were under certain circumstances exposed to tensile strains which rendered the use of wrought iron most desirable. The bridge was severely tested on several occasions by Major Rich, R.E., on behalf of the Board of Trade. Each rib, where practicable, with the exception of those adjoining the original bridge, was tested with eight of the heaviest locomotives and tenders, weighing 360 tons, or thereabouts, which were allowed to stand on, and also to run over at speed; and the whole structure was then tested with twelve locomotives and tenders, weighing 530 tons or thereabouts. The ribs deflected uniformly, when fully loaded, to the extent of ¾ in. at the centre; the corresponding ribs in the adjacent spans at the same time showing a rise of ¼ in. at the centre. The girders over the land spans, when fully loaded, showed a deflection in the centre of ½ in. The cross girders, when a pair of driving-wheels rested exactly upon them, showed a deflection in the centre of ¾ in. The permanent set in each case was scarcely appreciable. Careful observations had been made for nine months as to the effect of changes of temperature upon the structure. This effect was limited to a rise and fall of the crown of the arches, amounting to a maximum of 1½ in. and a movement at the free ends of the land arch girders of 1½ in.

The total cost of the bridge, including the land spans, had been 245,000l., which was equal to about 2l. 13s. per superficial foot of space covered, or about 38l. per lineal foot of single line. The bridge was completed in seventeen months; the whole of the ironwork having been supplied and fixed by Messrs. Ormerod and Grierson, the sub-contractors.

The high-level line of the London, Brighton, and South Coast Railway Company, with a branch line from the Wandsworth-road, consisted mainly of a viaduct of brickwork, which was described. The bridges were of a heavy character, comprising eighteen spans in wrought iron, ranging from 26 ft. to 150 ft., three spans in cast iron of from 60 ft. to 70 ft., and nine spans of brick in cement. The bridge over the London and South-Western Railway had a central span of 149 ft. and two side spans of 47 ft. each, and had two main girders of lattice construction continuous throughout. The centre span was erected without the use of scaffolding, by putting together the bottom flange and lifting it into its place, supporting it by temporary truss-roads, and then, erecting the remainder of the girder upon it, inserting the tension bars from either end till they met in the middle.

An adjoining bridge, of 120 ft. span, was of similar construction. The main girders, weighing 106 tons each, were built on the viaduct, and, when put together complete, were each rolled over into their places during the night, an operation occupying but four hours.

The other lines of this system were afterwards described, and it was stated that these works, which were three years in progress, comprised a length equal to nine miles of double line, of which five miles were on viaduct, and had cost for works only, including the bridge over the Thames, the sum of 910,000l. The high-level line of the Brighton Company, which was entirely on viaduct, had cost, including permanent way, stations, and signals, and the numerous heavy bridges, 45l. per lineal yard of double line. The whole of the works had been executed from the designs and under the superintendence of Sir Charles Fox, M. Inst. C.E., and the author, Mr. Edmund Wragge, being the resident engineer. The contractors were Messrs. Peto, Betts, and Crompton, Messrs. Lucas Brothers, and Messrs. W. and J. Pickering; Mr. J. Heywood, Jun., executing the ironwork for the Brighton Company.

STEEL RAILS—THEIR STRENGTH AND ECONOMY.—On the main lines, where the traffic is heavy and fast, the adoption of steel rails is only a question of time. Of this there can be no doubt. A well-made steel rail has at least tenfold greater durability than iron, and nearly double greater stiffness and strength for the same section of metal, and therefore much safer. Upon lines through sparsely settled sections of the country, and upon branch or spur lines of small traffic, iron may be continued in use, perhaps, without detriment in an economical sense; but as fast as the traffic is developed to any considerable amount, steel must of necessity take the place of iron. With regard to the greater wear of steel rails, the experimental tests, in England, to which we have often referred, show that one steel rail has outlasted or outworn twenty-five iron rails, the traffic being identical. In discussing the question of the comparative wear and economy of the two metals, we desire to keep so far within bounds as not to appear to be romancing, and therefore we estimate the life of the steel as only ten times greater than that of iron; but it is due to truth to state the above remarkable result of the test tried on a road where the traffic is exceptionally heavy and severe, and where the steel rail, at last accounts, after wearing out twenty-five of its iron rivals, was still in good condition. In view even of all the facts presented by the great test in England, and the favourable results by use in the United States, we do not expect our railway managers to rush pell mell into the use of steel rails. On some of the roads of light traffic steel is not required at all; on others or heavier traffic the question of economy is still an open one; but on roads of large traffic, heavy engines, and quick working trains, there is no question as to the economy of using steel rails.—*American Railway Times.*

THE LATE PROFESSOR MCGAULEY.—We hear that the committee for the relief of the widow and four infant children of Professor McGauley, late editor of the *Scientific Review*, have at present collected about 180l., including a contribution of 50l. from the Royal Literary Fund. Sir D. Brewster is chairman of the committee, the list of which includes Lord Richard Grosvenor, M.P., the Hon. S. Bethell, Mr. Hume Williams, Mr. John Hollingshead, and Mr. Robert Richardson, C.E. (treasurer), of 20, Great George-street, Westminster, by any of whom further contributions will be received.

ON SAXBY'S METHOD OF TESTING IRON BY MAGNETISM.

BY F. A. PAGET, C.E.

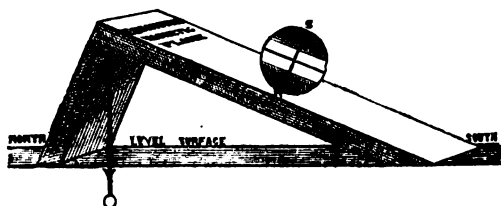
WE have pleasure in copying from *The Engineer* the following really valuable paper by Mr. F. A. Paget, a paper forming a singular exception to the usual character of the articles which appear in the same journal, and to which we wish to give the wider publicity it deserves:

It is well known to engineers that it is a most difficult, and often impossible, thing to find out the existence of a false weld in a forging, or of a blow-hole or honeycomb in an iron or steel casting. The only safe way of doing this is by carefully measuring the elongation of the piece under a given load, as with a false weld all the work is thrown on the diminished area at the defective weld, and the thicker parts are scarcely extended by the force which is perhaps rupturing the bar at the flawed spot. It need scarcely be said that there are many important cases where this process, or the equivalent but dangerous one of trying the effects of an impulsive force, could neither be mechanically nor commercially practicable. Every one knows that a simple method by which internal flaws and solutions of continuity in constructive details could be easily detected would be of enormous value to the world. Such a method has undoubtedly been discovered by Mr. S. M. Saxby, R.N., who has very judiciously been allowed by the Admiralty, during the course of this year, to experiment with it in the royal dockyards. Though comparatively new, and not yet completely worked out, the process will possibly have a yet more extended application than finding out only mechanical flaws in iron, and possibly in cast iron and steel.

The principle upon which Mr. Saxby's method is founded is so simple that it certainly seems strange that it had previously escaped notice. It has been known for nearly a century and a half that when a bar or any mass of soft iron is placed in the position of the dipping-needle it is at once sensibly magnetic, the lower extremity being a north pole in our latitudes, and the upper extremity a south pole. In the southern hemisphere the poles are of course reversed. The same action, only weakened, takes place in a bar hanging in a vertical or any other position, only the effect is weaker the more the position of the longitudinal axis of, for instance, a long bar departs from that of the magnetic dipping-needle.

Diagram 1 shows, in a rough manner, the positions, with regard to each other, of the magnetic dip of our latitudes with its equatorial magnetic plane. A sphere of soft iron, homogeneous

DIAGRAM 1.



in its internal structure, and without any solution of continuity within its mass, would, in section, have south polarity where marked S, a neutral state in its centre where left white, and an opposite north polarity at N.

Diagram 2 illustrates, as far as can be done by hatching, the magnetic condition of a bar of very homogeneous soft iron, lying east and west, or, better, in the exact equatorial magnetic plane.

DIAGRAM 2.

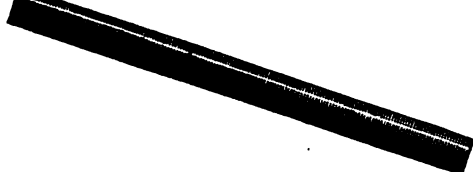
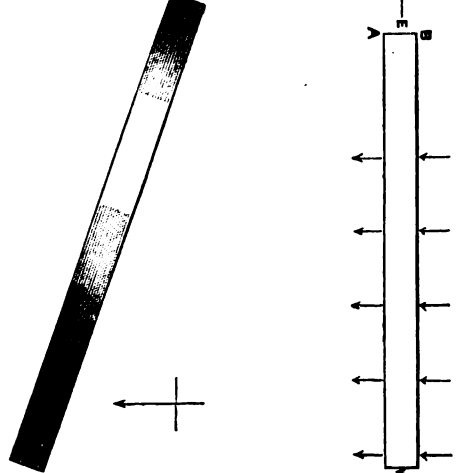


Diagram 3 shows the magnetic condition of a similar bar lying in the dip-plane.

DIAGRAM 3.



When, therefore, as in Diagram 4, a small compass-needle is slowly passed in front of a bar of very good iron, placed in an east and west direction, the needle will not be disturbed from its proper direction, which is of course at right angles to this, or north and south.

All this refers to regularly homogeneous bars of best quality—to bars without any mechanical solutions of continuity. With internal flaws or interruptions of continuity the bar is no longer

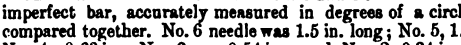
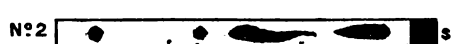
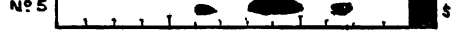
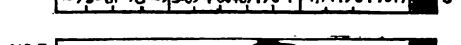
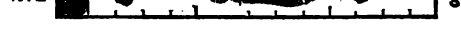
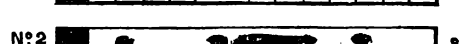
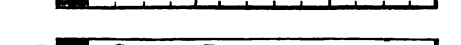
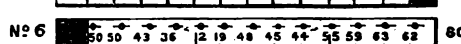
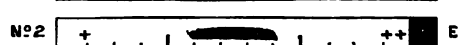
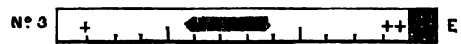
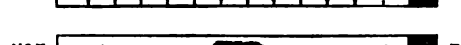
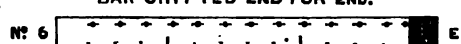
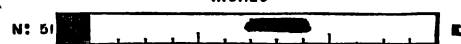
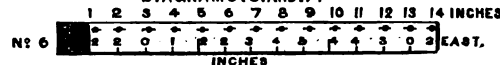
regularly magnetic. It has long been known that a good compass-needle, or a good permanent magnet, must be homogeneous, and without flaws, in order to take and retain its maximum amount of magnetism. In a word, any mechanical solution of continuity is accompanied with a polar solution of continuity, and the given bar or mass with flaws—whether permanently magnetised or temporarily so by the inductive action of the earth—is no longer one regular magnet, but several different magnets, with the different magnetisms separated from each other. The delicately poised magnet of a compass can thus be made to tell the presence of such solutions of continuity. The annexed cuts, Diagram 5, showing the actual results of the test

DIAGRAM 5.



with a $\frac{1}{2}$ in. bar, 12 in. long, will illustrate the manner in which the compass magnet is affected by the presence of cracks, of solutions of continuity, in the bar, which is supposed to be lying in the equatorial magnetic plane, or east and west. The magnet was traversed in a parallel line with the centre of the bar. As long as the iron was perfectly sound the needle stood at right angles, in its proper position, in fact, without being disturbed. Such a position is shown at B. Slight deviations had previously been caused, getting repeated towards the middle of the bar, as indicated by the two small arrows there. On traversing the needle towards the end—and a quick to-and-fro motion is of great use near a suspected spot—it got gradually deviated at A, until it entirely reversed at C, indicating the presence of the flaw, shown in the full-size cross section, after cutting the originally larger bar at that spot. The following diagrams, Nos. 6 and 7, are extremely interesting, as they afford proofs of the great accuracy of the method.

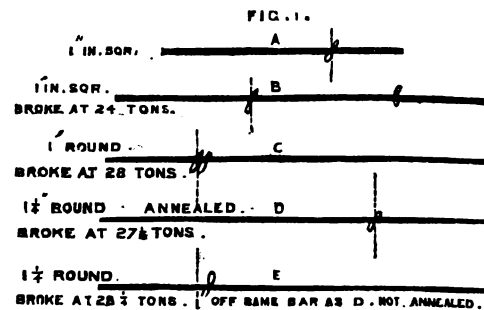
DIAGRAMS 6 AND 7.



The actions of different small needles under the influence of an imperfect bar, accurately measured in degrees of a circle, are compared together. No. 6 needle was 1.5 in. long; No. 5, 1.2 in.; No. 4, 0.63 in.; No. 3 was 0.54 in.; and No. 2, 0.34 in. long. The amounts of the temporary disturbances are of course measured by the number of degrees the needle was deviated. The bar of iron was first tested in the magnetic equatorial plane, and certain disturbances of the needle showed themselves, indicating internal faults. On turning the bar end for end, but still in the magnetic equatorial plane, the same deviations occurred, pointing to the same faulty spots. With the bar lying in the magnetic meridian the needle was similarly deviated, though the indications thus obtained would evidently not be so practically clear and easily obtainable as when the bar was in the magnetic equatorial plane.

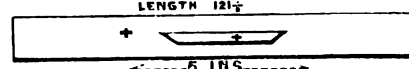
By the enlightened permission of the Admiralty Board, Mr. Saxby, as stated, has already been allowed to test his method in various ways in the royal dockyards of Sheerness and Chatham, and we will describe some of the practical results of these experiments. Amongst these were a number of very remarkable trials conducted in the presence of the master smiths, the foremen of the testing-houses, and several of the chief engineers of the royal navy. Mr. Saxby, for instance, was requested to find out the weakest spots in a number of bars, and to tie a string or make a chalk mark on each spot. Immediately afterwards all

these bars were put into the testing-machine and broken. Their history is given below in the annexed cuts (Fig. 1), the prediction having in every case been verified. The bars are shown by lines to scale, and a scroll is placed where the weakest part was found out by the needle. The vertical dotted lines indicate the spots where the several bars broke.



The smiths of the royal dockyard seem to have properly tried Mr. Saxby's powers in almost every possible way, and most ingenious devices were sometimes resorted to for the purpose. A. examples out of many, in the centre of a bar (Fig. 2), of 1 in.

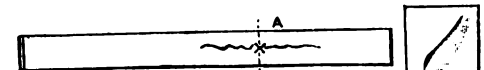
FIG. 2.



square forged iron, was welded a piece of unmagnetised steel about 5 in. long. The needle detected a fault at about the centre of the piece of steel.

In the $\frac{1}{2}$ in. round bar, 12 in. long (Fig. 3), it was discovered by the oscillations of the needle that the bar was flawed, and more especially at A. It was then gently cut, and the section

FIG. 3.



was seen to have the appearance indicated by B. It had a considerable crack, amounting to a cavity, as shown in the cut, and the structure surrounding this crack was partly crystallised and partly fibrous.

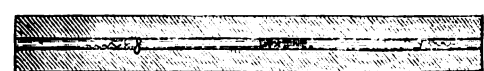
Into a piece of 1 in. gas-pipe had been inserted, unknown to Mr. Saxby, an iron plug at each end, as shown in Fig. 4. The

FIG. 4.



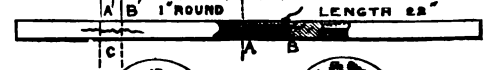
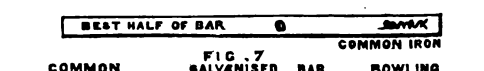
magnet soon detected the central break in the continuity of the iron mass, as shown by the position of Mr. Saxby's mark at A. A somewhat similar case was that of a bar (Fig. 5), 1 1/2 in. in diameter and 16 in. long, which was drilled from end to end with

FIG. 5.



a $\frac{1}{2}$ in. hole. A short steel bolt was fitted into the middle of the bar, and $\frac{1}{2}$ in. iron was welded into both ends. The small cross in the middle of our cut shows the centre of the steel bolt as determined, and the two other crosses indicate small faults—of course unknown to the smiths. A bar (Fig. 6), welded together

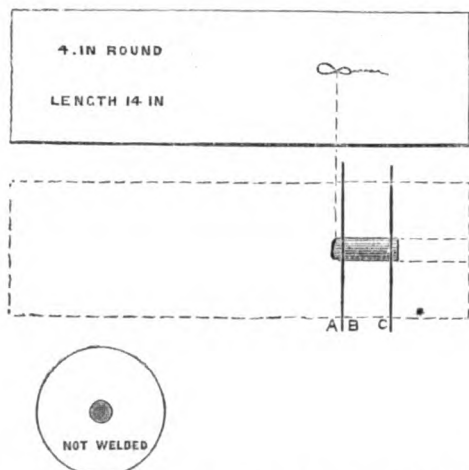
FIG. 6.



out of a piece of Bowling and a piece of common iron, had, at about its middle, a drilled hole, into which a magnetised steel pin had been rivetted. The compass magnet soon found out the pin, the difference in quality of the two ends of the bar, and also an unsuspected fault at the end, indicated by the zigzag line. A bar of round iron (Fig. 7) was brought to him painted over; it had been "jumped together" in three different pieces and qualities of iron—a bar worked up out of scrap of galvanised iron, another of common iron, and the third of Bowling, as illustrated in the cut. The needle detected very unequal qualities, the verdict being that the bar was unfit for being manufactured into any article. The bar, Fig. 8, bright as if just turned up in the lathe, was put into Mr. Saxby's hands. It was 1 in. in diameter, 22 in. long. He soon pronounced one end to be better than the other, and was accordingly told that the end to the left of the cut was of the best Yorkshire Bowling. The compass magnet showed the bar to be faulty at A and B, where marked. It was then explained that the best end of the bar had been screwed into the tapped end of the other, a

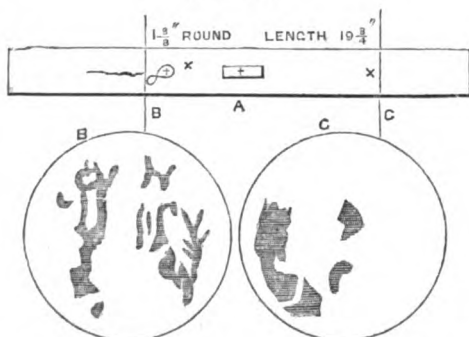
small space at B being filled with magnetic iron ore. The length of the screw, together with the cavity, is about 2 in., and the points A and B indicate the end of the cavity and shoulder of the bar at the base of the screw. Two small unsuspected defects were also found, and their existence proved by cutting the bar at A' and B', the slight defects being attempted to be shown in the woodcuts A' and B'. The following is a very remarkable experiment, and it affords much food for thought. A 4 in. round bar, Fig. 1, 14 in. long, had a $\frac{1}{4}$ in. hole drilled into it at one end, into which a bolt of unmagnetised steel was inserted and welded up with the end of the iron bar. The magnet detected a spot as marked by a scroll in the upper figure,

FIG. 9.



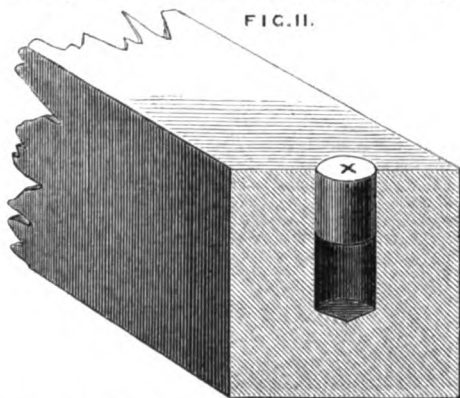
but its other end could not be found. The needle only testified to a weakening of the magnetism as if towards the right hand of the mark. From this it was inferred that this mark showed an unwelded portion of the bolt, and that its outer end had made a true weld with the iron. This was found to be correct on cutting up the iron. A, in the figure below, and the end view A, show the unwelded hole in the bar. Into a hole in an 1 1/2 in. round bar, Fig. 10, 19 1/2 in. long, there was rivetted an iron plug. The two were then hammered into each other as much

FIG. 10.



as possible. Mr. Saxby's needle detected the rivet, and his mark, A, hit exactly upon its centre. At B and C two faults were also discovered, and their presence confirmed in cutting the bar at B and C, as shown in the respective sections. A 2 in. square bar (Fig. 11) was brought to him, thickly painted over. The needle found out a very great

FIG. 11.



defect, and this defect was indicated by a cross mark. It turned out that Mr. Saxby had hit upon the very centre of an iron plug, which had been driven into a hole drilled in the bar. He was asked by the master smith of Sheerness to try the weld of a new stud link which had been put into a chain cable. Externally the weld appeared good; the compass in Mr. Saxby's hands soon showed the weld to be unsound. He indicated this spot with a chalk line, Fig. 12, and on cutting and breaking the line at that mark, faults were found in it, as shown in the sketch, in which the chalk mark is also indicated. An old mooring-ring, Fig. 13, which had been reduced by the smith down to 28 in. in diameter outside, and which was of 4 in. round iron, had been tried in the usual way in the testing-machine. After withstanding the test very small cracks showed themselves, as at A, in the figure. The compass needle, however, detected still greater faults, as shown by crosses in the dotted

sketch, testifying to a flaw that, it was inferred, would probably cause the ring to break somewhere between the 4 1/2 in., as marked on the engraving. The ring was then again tried in the testing-machine. It actually broke at the spot indicated by the thick line in the dotted ring. The weld showed itself to be good, but

FIG. 12.

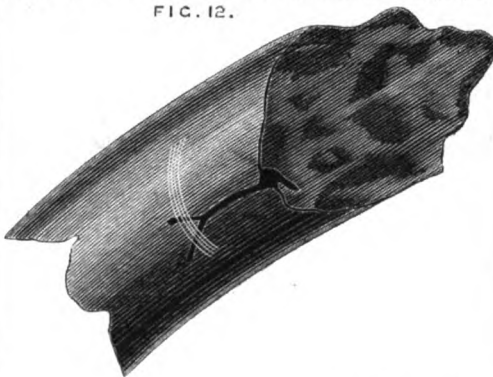


FIG. 13.

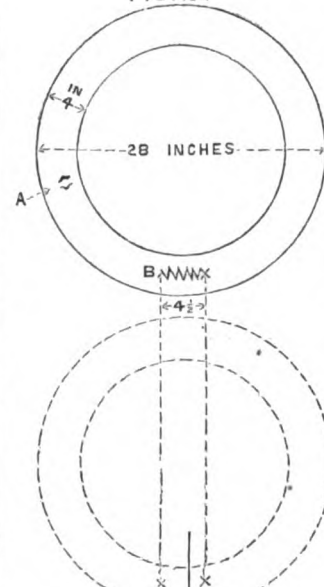
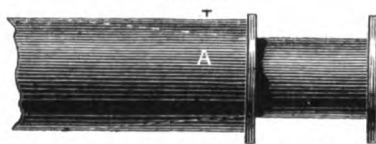


FIG. 14.



FIG. 15.



magnetic examinations, in order that they might be subsequently compared with what was known as to the actual quality of each bar. A bar, 1 1/2 in. round and 3 ft. 11 in. long, was pronounced by the compass needle as being not of the same iron throughout, and with a south end better than the other. It was then stated by the master smith to have been made up of pieces good and bad. A rather shorter bar was found to be good iron, but doubtful in condition; it was afterwards explained to be "uncertain," and on testing it in the machine it was stated to be "crystallised." A third piece was found to be of very good iron, but with slight irregularities; the smiths stated it to be scrap iron, and the best to be got in the shop. Two pieces of 1/2 in. manufactured iron were discovered to be not good. Another piece of 1 1/2 in. bar was found to be good iron, though made of different qualities—it had been afterwards annealed. With another bar, to Mr. Saxby's written question whether it was not steel, it was answered that the bar in question was a near approach to steel, being a piece of galvanised wire rope welded up. To the remark that another bar was unfit for use, he was told that it had been twisted round when at a low heat, and then hammered cold. Some singular proofs of the power of magnetic testing over the ordinary methods of determining quality and condition of iron have been shown. Pieces of iron brought for testing by most able and experienced master smiths, of such quality as would be selected for the most important work, have, on being tested, been marked at spots as defective, and, on cutting have accordingly been found at those spots to be partially fibrous, partially crystallised.

The following experiment was made in order to throw light on an important practical question in smith's work: A certain 1 1/2 in. round bar 17 1/2 in. long was specially worked, and had been brought to be tested without anything of its history being known to Mr. Saxby. He found that in the middle of its length it was seriously faulty, and even unfit for use. He was then told that the bar, though solid, had been "upset" in the middle

of its length, and then hammered down to its original diameter at a temperature below welding heat. This will be held to confirm the opinion of good workmen that "upsetting" should be done at a temperature as near as possible below that of welding.

Mr. Saxby has not yet been successful in testing rolled plates for lamination. In these, again, the neutral or zero lines should run at right angles to the dip in a homogeneous plate; but the more complex structure of the plates has made the investigation more difficult. Another difficulty doubtless consists in the fact that the usual shape of a plate does not allow the magnetism to separate itself in such a marked way as in a bar, usually longer by many diameters. The investigation, with a resulting perfect method, can scarcely be said to be completed in this direction. The chief difficulty at present seems to be that the internal structure is too irregular.

Up to the present but few experiments have been made with steel, and very few with cast iron; those already made have, however, been satisfactory. Any difficulty that might be supposed to attend the presence in wrought iron of what is termed by the Astronomer Royal subpermanent magnetism is easily overcome. A few taps on the end of a bar of wrought iron, when lying east and west, sufficient to cause vibration, would demagnetise it, and leave it in a fit state to be examined by the needle; any polarity subsequently found would indicate either a steely nature of the bar or inferior iron. As showing the necessity for caution as to whether or not bars being tested are permanently magnetised, may be cited the following experiment: Three bars were presented to Mr. Saxby to be tried. He found that all three were permanently magnetic, using—after the trial with the pocket needle—percussion to determine this point. He at first declared that all the three showed the same behaviour as to the magnetic test. He was then informed that one bar had been made up of "scrap galvanised iron," or of old pieces of zinc galvanised plates and wire rope. The zinc is not, as might at first sight have been expected, sublimated by the heat, and accordingly the iron produced is of about the worst possible character. The second bar consisted of the best Bowling iron, and the third was of the best Chatham make. But Mr. Saxby was soon enabled to trace out the fact that the three bars had not merely been lying side by side for some five hours previous to the test, but that they had all been kept on racks lying nearly in the magnetic meridian for above a year. A similar but new Bowling bar from the same rack as the bar tested was found to be strongly magnetic; and another similar zincified bar was partially magnetic. The bar made at Chatham was found to behave towards the needle as a piece of good iron should. Mr. Saxby hence concluded that the Bowling bar, which, indeed, had much more the character of steel than of iron, had magnetised the two others. Tested as a steel magnet, it was found free from fault.

Some curious experiments would seem to show that it is not indifferent whether a bar be forged in the direction of the magnetic meridian or in that of the magnetic equatorial plane. Four pieces of the best Bowling iron were forged, two in the magnetic meridian and two in the equatorial plane. They were worked down to 1/2 in. square from 1 1/2 in. As the result of a small number of experiments Mr. Saxby considers that it is best, for ultimate tensile strength, to have the anvil standing E. and W., and for a high elastic limit N. and S.

At first sight it might be believed that as almost any flaw will cause a disturbance in the compass needle, it would be difficult to tell a serious solution of continuity from a small crack. But this is met by the obvious reflection that the range or distance through which the needle is disturbed must be taken into account. On reflection it will be noticed, however, that an object rather short in relation to its diameter is more difficult to try than a long bar.

Some brief considerations will now determine the value of Mr. Saxby's invention to engineers, whether for trying new work of all kinds, or even working details in a suspicious state. In estimating the value, in the widest sense of the term, of any wrought-iron forging, three qualifications may be considered as governing:—(a) its limits of elasticity, or the amounts it will yield in any given direction without taking permanent sets; (b) its ductility, or the permanent alteration it will take before actual rupture; and (c) its ultimate resistance, or the amount of the load it will stand, per original unit of cross sectional area, before actual rupture. These three qualifications in a complete forging are evidently—1, the absence of defective welds, or of large solutions of continuity in the mass; 2, the absence of smaller flaws or solutions of continuity—either due (a) to the presence of scoria or slag, causing what are termed "greys," or small flaws, either parallel or across the longitudinal axis of a bar, or (b) to cracks (often unsuspected) caused in the working, when portions of the forging are too cold; or (c) to actual separations at the facets of the elongated crystals of which iron always consists, and due to loads of whatever kind beyond the elastic limit; 3, the chemical constitution of the bar—such as its freedom from phosphorus, sulphur, arsenic, silicium, manganese, &c. (apparently everything but carbon in small quantities)—originally governing its mode of crystallisation, and hence more or less its elasticity, ductility, and ultimate resistance to rupture. Now Mr. Saxby's method can detect the presence, and negatively of course the absence, of small or large solutions of continuity. It can detect false welds, smaller flaws caused by bad workmanship or wear, and, we believe, what is commonly termed "crystallisation," which will, probably, once be generally acknowledged to consist in a disruption or parting of the facets of the amorously arranged crystals of which iron is built up. It can, of course, only detect the results of the chemical constitution of iron, as evidenced in the less perfect cohesion of the crystals when alloyed, in relatively considerable quantities, with foreign bodies. There is little doubt that the magnetic method is a test of the homogeneous character of the iron, and of its freedom from fissures and cracks, and so far it undoubtedly forms a test of quality. It will appear scarcely credible that a common pocket compass needle should be able—almost like the divining rod said to be used for finding out springs of water—to discover important defects in large iron bars. A mere statement of the fact does sound almost incredible until the simple means actually employed are explained.

NEW ORIENTAL MAIL CONTRACT.

TO THE EDITOR OF ENGINEERING.

SIR,—The P. and O. Company, it appears, has obtained a renewal of its contract for the conveyance of the mails to the East, and the term is extended from six to twelve years, and the subsidy is increased from 230,000*l.* to 400,000*l.* For this increased payment, however, there is to be some increased service performed, and we are to have a weekly mail of twenty-nine days to Calcutta, and a weekly mail of twenty-four days to Bombay. It has always been clear to me that, in justice, the P. and O. Company ought to have the new contract, and that, moreover, this result was inevitable, since nobody else would be prepared to undertake it. A call for tenders to carry an important mail does not by any means stand in the same category as a call for tenders to supply shipping, stores, or other commodities which the Government may from time to time require. In the one case a large capital has to be expended upon steamers fitted only for a special purpose, and upon dockyards and other succedanea of an efficient organisation which would become useless if the line of communication is superseded or placed in other hands; whereas stores are either not produced, or are sold in some other market, if the tender for them is not accepted; and the freight of sailing ships is as marketable a commodity as any other, and, if declined by the Government, will be accepted by some other competitor in the general market. Far otherwise is it when a great establishment has been created to supply a commodity such as the Government alone requires, as it is plain that no sane man would invest their money in the expensive machinery fitted to the special requirements of an important mail line, except on the condition, either expressed or understood, that the business shall be continued in the same hands, except in case of flagrant default, for such reasonable time, at least, as will have sufficed fairly to reward the investors. But not only would it be unjust, except on some solid and weighty ground, to dismiss an experienced and tried contractor in favour of some new competitor; it would be in the highest degree impolitic, as the effect would be to disincite every one to invest his capital in a business exposed to such risks, so that, if the rule continued to be followed, no offers would be forthcoming when a contract is desired, or else the great companies who are the present contractors would combine to coerce and embarrass the Government, and we might be left without an ocean mail service at all. The proper course to be pursued in conducting such arrangements is for the Government to make up its mind what it wants, and what measures of efficiency and cheapness are demanded by the progress of mechanical improvement and the increasing wants of the public. Corresponding conditions should be exacted from the contractor, and it is only when he fails or refuses to fulfil them that the intervention of other parties should be requested. This, I am persuaded, will be found to be the course most conducive both to cheapness and efficiency. On the one hand, contracting companies would be saved from the mortal apprehension that, at the end of a brief term, they may be thrown overboard in favour of some other suitor whose political interest may for the moment be more powerful; and, on the other hand, the Government would be able, partly to induce, and partly to extort, such improvement from time to time as was reasonably demanded; whereas now, when tenders are called for and none are forthcoming, except from the old contractor, the Government is left powerless in that contractor's hands. When tenders are called for, it is felt by all parties that it is impossible to award the contract to any but the old contractor, except in the event of some serious default, and new men are unwilling to send in tenders which they feel are intended only to enable the Government to drive a harder bargain, instead of putting something in their way. Hence, as in the present case, it sometimes happens that only one tender, that of the old contractor, is presented, and the Government has no option but to give substantially what is asked.

The receipts of the P. and O. Company, it is well known, have for some time been falling off, in consequence of the competition of the French mail company, which enjoys a much larger subvention, and which, consequently, could undersell the English company; and the alternative has, consequently, been presented to us either to give the English company more money, or to give up our present steam communication with the East, and to get our mails carried in the French vessels. This last expedient is the one to which the Post Office inclined, and for which it is not to be blamed, as it has naturally the same aspirations as any commercial association in getting its work done on the cheapest terms possible. Accordingly, in the last session of parliament Mr. Hunt, on behalf of the Treasury, intimated that it was hoped the French company would be induced to tender for the conveyance of our mails—a sentiment universally reprehended; for although it was excusable for the Post Office, looking only to departmental interests to advocate such a policy, the Treasury, it was felt, was the proper conservator of the interests of the empire at large, which could not be subserved by allowing our steam communications with our Eastern empire to be placed in the hands of a foreign power with which we might any day find ourselves at war. It is not merely for carrying mails that such a fleet as that of the P. and O. Company deserves to be subsidised; it is for keeping up a regular and frequent communication with our Eastern dominions, and for performing the duties of an auxiliary navy, telling from its mobility, and capable at any moment of ready expansion. The French company, no doubt believing that the English Government must see all that, and that the invitation given to it to tender was only a feint, very properly declined to be made a cat's paw of, and Mr. Hunt was then left face to face with the company to which he had given notice to quit, who were losing money by their existing contract, and who very properly resolved that, in any new contract, they should be fairly remunerated for their expenditure. They consequently asked 500,000*l.* a year, instead of 230,000*l.* But they proposed to do somewhat more work, and they finally abated

their demand to 400,000*l.* a year on the condition that the contract should be for twelve years, instead of six, and that if their dividends fell under 6 per cent., they should be authorised to draw any portion of the odd 100,000*l.* required to make them up to this amount. On the other hand, they agreed that, if their dividends exceeded 8 per cent., they should hand over one-fourth of the excess to the Government.

There are two conditions of this contract which have afforded just ground for animadversion. The first is the partnership arrangement, and the second is the insufficiency of the speed which is to be maintained—namely, 10 knots in the Mediterranean and 9½ knots on the other side of Suez. The European system of railways may now be supposed to converge at Brundisi, and the Indian at Bombay; and the total sea distance between England and most parts of India being now so much abridged by the establishment of railways at each end, it becomes of more importance than ever that the connecting link of steam navigation should have the highest possible measure of efficiency in order that the average speed may not be made low by the slowness of the steamers on this part of the line. Just as it is only since the establishment of railways in England and Ireland that the demand for efficient steamers across the Channel become so exigent, so the spread of the railway system in Europe and Asia renders the demand more than ever imperative for an oriental Holyhead line to connect those dis severed lines of railway. On a former occasion I pointed out the absolute necessity of swift lines of steamers being established between Brundisi and Alexandria, and Suez and Bombay; and it is a mark either of negligence or ignorance on the part of the Government that it has omitted to prescribe this condition. In Parliament, the omission has provoked much hostile criticism, to which Mr. Hunt has replied that, now there is telegraphic communication with the East, the acceleration of the mail was less important, and that he had understood, from mercantile men, that what they mainly wanted was regularity, which was more important than high speed. To bring this logic home to the apprehension of the Irish members, it may be thus translated—that instead of the swift steamers now plying across the Channel, it would be permissible to substitute slow ones, which would prolong the duration of the voyage so much that a traveller would require twice the time, and a letter twice the time, to pass from London to Dublin that is necessary at present. If any exception should be taken to this doctrine, the answer is, that there is a telegraph now between the places, which persons in a hurry may use, and that merchants in their letters prefer regularity to expedition. We are not told why, in such an important line of communication as that between the Eastern and Western worlds, we should not have both regularity and expedition; nor are we told how such a telegraph as that to India, whose messages are costly, irregular, and often illegible, can sensibly abate the evils of a slow post, not intended for merchants alone, but for the entire community. It was a mistake to continue the subsidy to a line to Calcutta, and it would be much better to award the subvention appropriated to it to increase the speed of the line to Bombay. I believe that, after the mails are transmitted by way of Brundisi and Bombay—and they should all be so transmitted—passengers and goods will continue to be carried from Southampton to Alexandria, and from Suez to Calcutta, as at present. But the vessels maintaining the intercourse on these lines of communication should be cargo vessels of moderate speed, carrying passengers at a low rate, and also troops; and, instead of a subsidy, the conveyance of a certain number of soldiers yearly at certain rates should be guaranteed to the company. This would have been a better and cheaper arrangement than the construction by the Government of steam transports of their own, which can only be kept up at a very heavy expense. On the whole, the Government have shown very little capacity in the adjustment of this contract. It was, in the first place, a great mistake to apply to the French company—or to threaten to apply—to ask it to tender. It was also a mistake to give notice for the termination of the contract until the Government had made up its mind as to what it wanted, and wherein the company had unquestionably fallen short of the reasonable requirements of the times. For giving the contract to the company again the Government can claim no credit, as there was nobody else who offered to take it; and by this circumstance alone we are probably saved from a repetition of the Australian experiment, where a contract was given to inexperienced persons, who completely broke down. We must join in the testimony to Mr. Scudamore's talents and tact, which in Parliament have obtained praise from all parties. But he represented the Post Office views and interests alone; and it was no part of his function to insist upon the imperial advantages of a more rapid communication with our Eastern possessions. To this the Treasury, as the highest department of the Government, and the actual negotiator of the contract, should have looked; and Mr. Hunt, as representing the Treasury, has little reason, in any respect, to be proud of his handy work. The only consolation to be discerned amongst so much blindness and presumptuous blundering is the manifestation of perfect fairness and sincerity on the part of the company itself, and these qualities justify the belief that the company, spite of the scurvy treatment it has received, will assist in the equitable rectification of any of the arrangements which are now pronounced to be defective. Whatever Mr. Hunt may think, it is quite certain that a very swift line of steamers between Brundisi and Bombay must be promptly established, this connecting-link being now required to unite the European and Asiatic railway systems. The Calcutta line should no longer aspire to be a swift—only a cheap line; and the French company would then find itself beaten on the one line, by swiftness and on the other by cheapness. Letters from France intended for India would go by the English line, if it was very much swifter, and many of the articles which are now carried in the French steamers would be carried in the English if they were carried at a much lower rate. There are none, or few, of the P. and O. Company's existing vessels

which are fitted in their present state for either line. But most of them would be rendered suitable for cargo vessels by cutting them in two and putting in a large and strong piece amidships, the power and all other things remaining the same. To quicken those of the vessels which, from their shape, were found to be suitable for a higher rate of speed would require other means. But the problem is by no means an insoluble one, and, whatever be the present disposition in any quarter, it is quite inevitable that a higher speed should be had. I hope that the company will look to the just requirements of the public, and signify to the Government its willingness to carry them out, of course on terms of fair remuneration. Such proposals, if made, will either be accepted or rejected. If accepted, the company will add to its prestige and have earned a new claim to the public confidence and approbation. If rejected, it will have shifted the whole responsibility on to the shoulders of the Government, who will thenceforth be held responsible for all the shortcomings that may be discerned.

I am, &c.,

ANGLO-INDIAN.

December 4, 1867.

THE TEES BREAKWATER.

THE engineer to the Tees Conservancy, Mr. John Fowler, of Stockton-on-Tees (not of Westminster), has made a report, of which he has favoured us with the following extract:

The South Gare breakwater was commenced in January, 1861, and during that year the siding was put in, and the embankment advanced 300 yards from the high-water mark at the railway.

During the next year the work was advanced about one mile, or as far as the Red Light, and on the 20th of December the first slag was taken down in large blocks; on that night, however, a heavy storm arose, accompanied by a high tide, which nearly destroyed all that had previously been done. On the 3rd of January, 1863, the regular deposit of slag in blocks began, and the commence of the work may be dated from then.

The quantity deposited and distance advanced during the five following years are as under, viz.:

Year ending	No. of Tons.	Distance advanced.
		ft.
Oct. 31, 1863	68,628	6780
" " 1864	213,282	988
" " 1865	264,489	580
" " 1866	249,831	379
" " 1867	270,240	242
	1,066,470	8969

It will be observed that, whilst the quantity deposited per annum has increased yearly, the distance advanced has lessened; this is accounted for by the fact that the depth, at low water has yearly become greater. Last year the depth was from 18 to 20 ft. at low water; the total depth from the rails to the bottom has been about 55 ft., the width on the top is about 70 ft.

The slag is brought from the furnaces on wrought-iron bogies in blocks averaging 34 tons each, and turned over the tip-rud and allowed to find its own slope. The action of the waves in the first instance washes it down on the sea-face, forming a hollow curve with an average slope of 4 to 1.

No alteration of the slope takes place after it is turned over on the inner face. After sustaining the action of the waves during one storm, the slopes are left firmly set.

As the breakwater has advanced towards the Channel, the intervening sand-banks have been washed away, so that now, instead of being 5 or 6 ft. above low water, the water is rippling over them at low spring tides, the consequence being that the waves, which formerly were broken on the outlying sand-banks, roll on with undiminished force upon the perpendicular face of the breakwater. At such times the tip end is driven back on an average about 40 ft., the broken slag being carried inwards and laid on both sides of the breakwater, sometimes on one side, sometimes on the other, in greater quantity according to the direction of the wave. Large accumulations have thus been formed on both sides of the breakwater, so that, except at the extreme end of the work, the heaviest storms do not affect the main structure. No advance is made during the continuance of the swell, the slag being taken inwards as fast as it can be put down. Hitherto the slag has all been conveyed by land; but since the sand-banks have been washed down, admitting the waves with so much greater force, it has been resolved to form a foundation by means of barges, keeping it from 200 to 300 yards in advance, upon which the waves may expend their force before reaching the land tip.

TOOLS AND TOOL-HOLDERS.

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to Mr. W. Hackney's letter in *ENGINEERING*, of November 20th, 1867, we have examined Holtzapffel's work, and have failed to discover the identity between the tools and iron tool-holders there described and our steel tool-holders and cutters.

We there find a description of a tool-holder in which round steel was used (which we are quite aware is in itself an old idea); but it is evident from what follows that a satisfactory arrangement for holding and using the round steel had not been found out, as Mr. Holtzapffel says he tried a tool such as described, and found it unsatisfactory in practice, and was led to adopt triangular steel in preference.

We quite agree with Mr. H. that there is much conservatism among our practical men; but, notwithstanding this, several important engineering establishments have thoroughly adopted our system, and are highly satisfied with the advantages they are reaping from its introduction.

We are, dear Sir, yours truly,

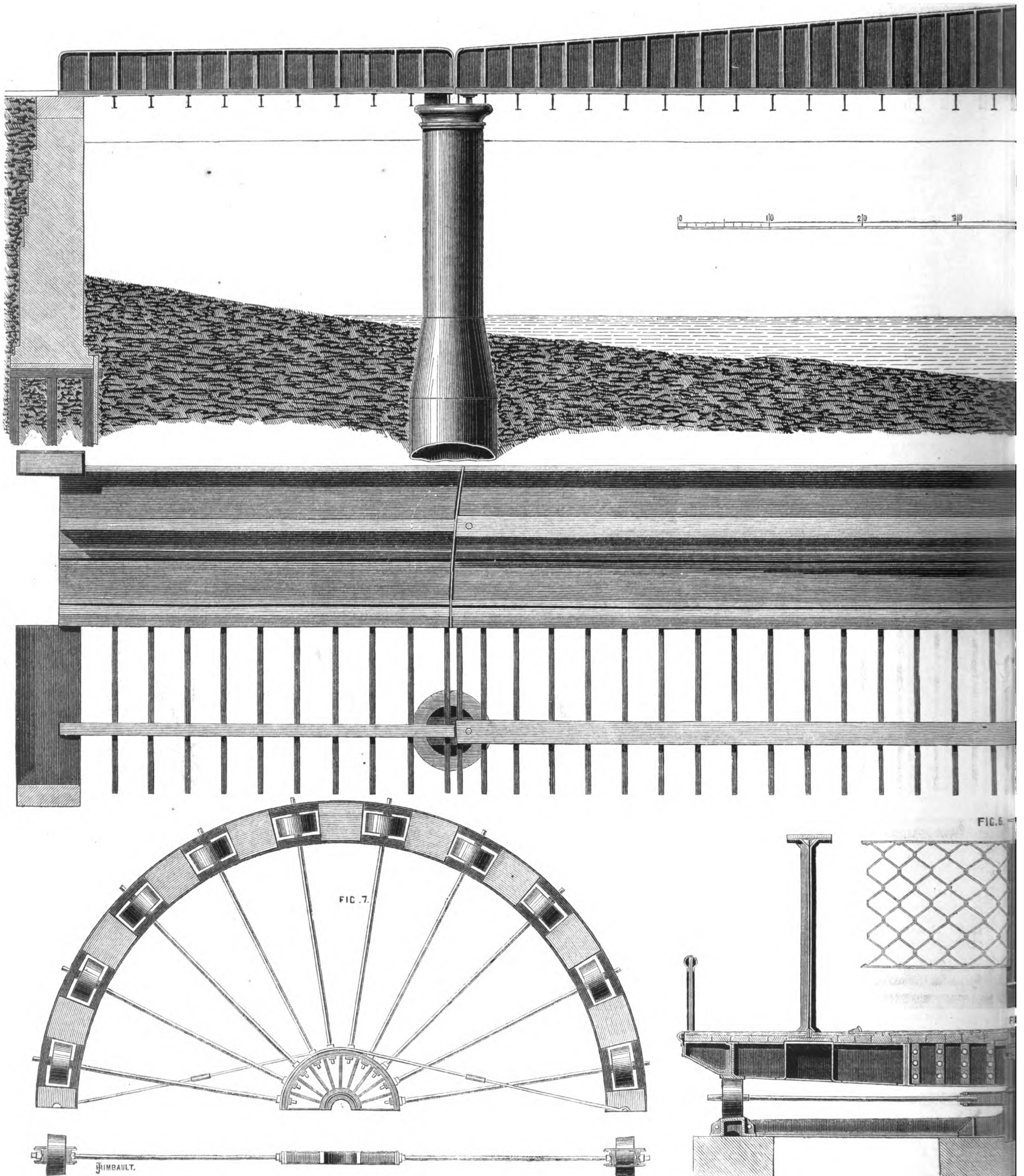
SMITH AND COVENTRY.

Manchester, December 10, 1867.

[We can print no more letters on this subject.—ED. E.]

HULL SOUT

MR. JOHN HAWKSHAW, ENGINEER; THE REGENTS
(For Descri



BRIDGE.

NAL IRONWORKS COMPANY (LIMITED), CONTRACTORS.
, see Page 547.)

FIG. 1.

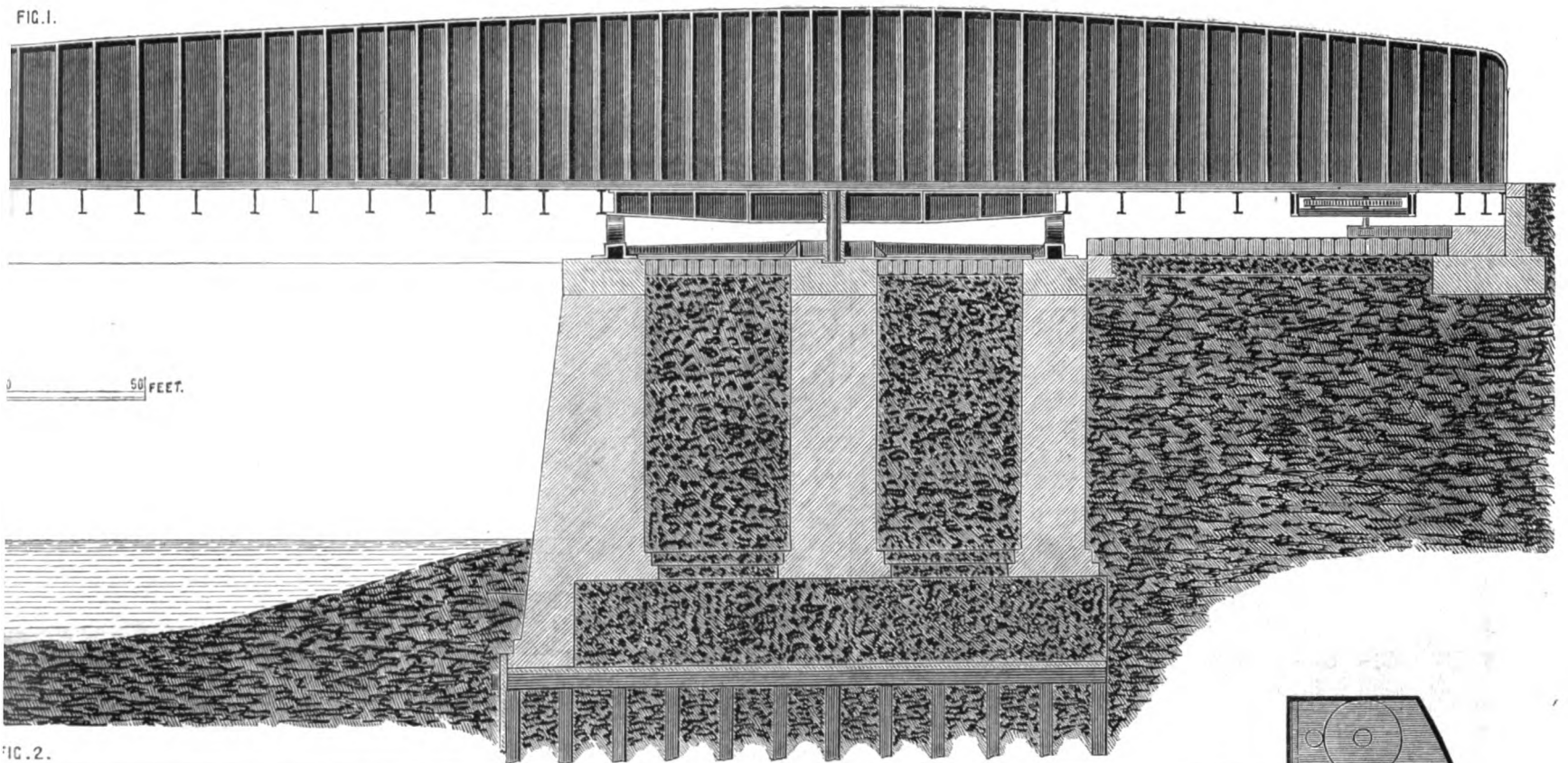
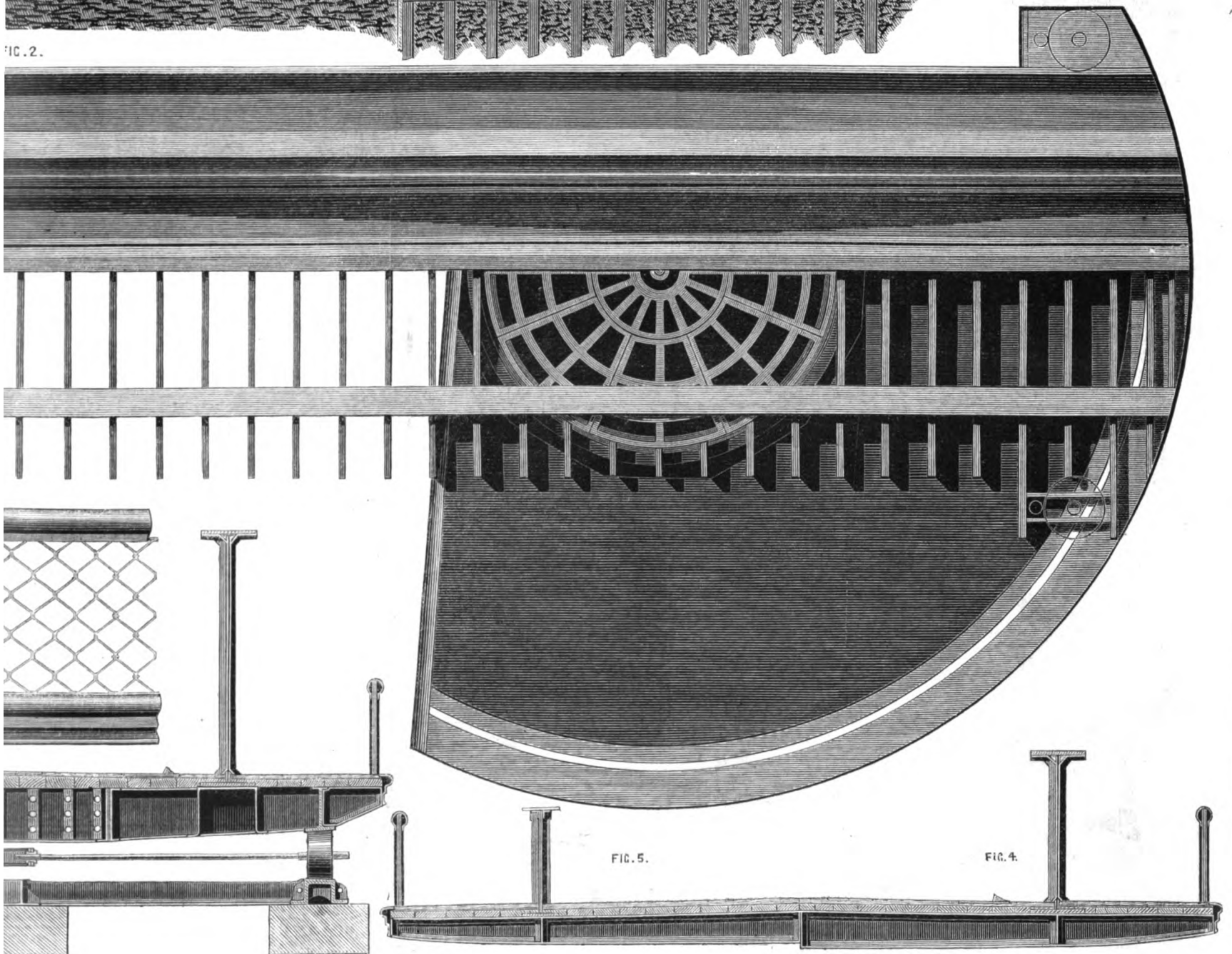


FIG. 2.



THE CITY FLINT GLASS WORKS, GLASGOW.

GLASS-MAKING is one of those branches of industry which existed for centuries before the name of an engineer was known to the world, and perhaps for this reason it has contrived to escape the closer and more general attention of engineers, and to continue most of its operations without the aid of modern machinery and appliances. In saying this we do not overlook that the glass-works of this and of other countries were amongst the first licensees of Mr. Siemens for the regenerative gas-furnace, and that to the success obtained with the Siemens furnace in glass-making the subsequent practical introduction of this most important invention has been, to a certain extent, due. Nor do we deny that there are steam-engines and revolving grindstones employed for cutting and polishing glass, and that these latter machines are fully as complete and well-arranged as such tools require to be. It is the principal and characteristic operation of glass-making, i.e., the blowing out of a cylindrical or spheroidal article from a bulb of liquid glass gathered at the end of a tube or hollow lathe spindle—to give the proper mechanical form—to a cylinder, which is kept revolving round its axis, for the purpose of giving a circular shape to the piece of glass attached to it, which at this moment is carried out in the same primitive manner in which it may have been practised in the time of the Crusades or of the Roman Empire. We have selected one of the most advanced and largest glass-works in Scotland as an illustration for our remarks, viz., the works of Messrs. James Couper and Sons, of Glasgow—the works in which Mr. Richardson, the invention of the Richardson process, is a managing partner. The glass made is principally flint glass, that is, a mixture of silicates, in which silicate of lead predominates. The raw materials for making this glass are siliceous sand, red lead, and pearl-ash (a mixture of alkalis); they are mixed in the proportion of three parts of sand, two parts of red lead, and one of pearl-ash. The silica, combining with the bases at a high temperature, forms silicates of lead and alkali, which in their mixture give the flint-glass. The operation is performed in fire-clay pots, made at the works from Stourbridge clay. The operation of blowing, for the production of a spheroid of glass, is too well known to require a description; but the processes immediately following deserve a closer investigation from a mechanical point of view. The production of a cylindrical article, or of a more or less curvilinear object of glass, such as a vase or lamp-glass, is by its nature an operation of lathe-turning. In practice, the glass-blowers take every possible pains to improvise a lathe without virtually having recourse to a machine of that kind. The pipe to the end of which the spheroid of glass adheres is placed in a horizontal position upon two straight and parallel supports, and rolled forward and backward upon them, so as to get the glass spheroid to revolve round its own axis. The tools which are used for widening out certain parts, or for curving or cutting others, are therefore in the precise position of lathe tools, only they must be traversed by hand to keep pace with the forward and backward rolling of the spindle—a very primitive process, and one requiring great manual dexterity on the part of the workman. Another important process is drawing out cylindrical or tubular pieces into lengths. A glass water-gauge tube, for instance, is drawn out from a large spheroid originally blown, this spheroid being kept revolving throughout the whole operation of drawing until a tube, say 10 ft. or 12 ft. in length is obtained, of properly cylindrical form and equal thickness all through. All this is work evidently destined to be performed by machinery, and the protestations of “practical” glass-makers and of their workmen, who pretend that no machine could possibly be employed for setting a glass bulb spinning round its axis, are of no value. The fact that the spindle must be frequently shifted for reheating the glass will only necessitate suitable provisions for so doing, but it does not in reality interfere with the question at issue. It is also perfectly probable that we can construct more powerful, more reliable, and more suitable blowing-machines than human lungs for producing a steady, uniform, and continuous blast, and that mechanical blast would raise the power of production and the speed of working in glass-making, the same as the substitution of mechanical labour for the exertion of muscular efforts has done, and is constantly doing, in other branches.

The operations of cutting and engraving are already done by machinery; but the glass-cutters guide their

articles by hand, and must rely on their eye and judgment for producing the designs and patterns upon the glass. In this respect more suitable machinery could be derived for some kinds of work by the employment of those principles which have made the watchmakers' ornamental lathe and engraving-machine an innovation of great practical success, and an object of admiration to every one who watches its performances. Messrs. Couper and Sons employ upwards of one hundred stones or machines for cutting glass. There is about an equal number of other machines employed in other accessory processes, such as grinding, polishing, &c. A set of very beautiful tools, worked by very skilful operators, is employed for engraving. The cutting tools for this operation are, strictly speaking, the points of little emery crystals dropped with the oil upon the edge of a small revolving disc of steel or copper; but the latter is, of course, practically looked upon as the cutter, since it imparts its form to the cut made by it. Each cut or line made by the engraving process is hollowed out or round, on account of the form of the cutter employed; and this assists, to a certain extent, in bringing out the peculiar shades in engravings on glass. A very interesting process of a purely chemical nature is etching by means of hydrofluoric acid. This process is carried out largely at Messrs. Couper's works. The hydrofluoric acid is transported, and manipulated with, in vessels of gutta-percha, since it attacks all glass or earthenware substances and most of the metals. The glass is painted with wax over all the parts which are required to be bright or raised, and the rest of the surface is covered with the acid. This dissolves the glass, and after a few minute the articles are removed from the bath and washed. The portion, attacked by the acid have a dull, rough, and opaque surface, while the parts protected by the wax remain bright, transparent, and appear slightly raised, as compared with the attacked portions. The City Glass Works employ a small but complete engineers' shop for cutting moulds and patterns for pressing glass, the presses being hand-worked and of a moderate size. There are also very numerous kinds of coloured glasses and opticians' lenses amongst their products.

ABYSSINIA.

To facilitate the landing of troops and stores for the Abyssinian expedition, it has been determined to construct piers at North Massowah and Annesley Bay, running some distance into the sea. These may hereafter prove useful for other purposes, having no connexion with the present expedition, and the works commenced for hostile purposes may, at some future time, contribute to the peaceful prosperity and wealth of this almost *terra incognita*. The pier at Massowah will be built on piles of teak wood, iron-shod and iron-capped. These piles have been prepared at Messrs. Nicol and Company's works, at Tank Bunder, Bombay, and, together, with the rest of the timber required for the pier, was, according to last advices, expected to be shipped for its destination about the end of last October. Annesley Bay seems, from recent accounts, to be well adapted for a harbour. Sheltered on the west by the Geedan hills, which throw out long spurs towards the water, it is also largely protected by the lower hills on the south and east. There is great depth of water, studded with an archipelago of rock-bound islands. A line of rail and a stone pier are building fast; heaps of stones were, on the dates last received, lying about everywhere, some of them damaged by the rough handling of careless natives; and the water-tanks had been landed ready for use. Sheds were in course of building to shelter some of the stores from the coming rains. Want of water and bad water were the chief drawbacks, and for many miles round nothing could be got but a brackish dusty-white [apology for the pure liquid, whilst that was selling at two annas a pint. Without the distilled water, there would have been great distress.

Large wooden bungalows, to be used as rest-houses by the troops, are, it seems, to be built at Massowah, and at stations sixty miles apart along the line of march, and, as they will each be large enough to accommodate one thousand men, they will undoubtedly be of great service. These bungalows, or sheds, were prepared at Messrs. Nicol and Company's saw-mills, and were shipped from Bombay early in October.

After all, Annesley Bay has been selected as the landing-place for the Abyssinian expedition, and not Massowah, as was at first thought would have proved the best locality; so the wooden pier intended for the latter place may be found useful for employment elsewhere. The pre-

cise spot for disembarkation having been chosen, the first care was to construct a landing-jetty, and a number of bungalows were employed in bringing stone from the opposite shore for that purpose, there being none in the immediate neighbourhood. A camp has been established about a mile from the shore at Zoula, to which, it is reported, there will be a tramway constructed. No store-sheds can be put up on the seaboard, as the ground is on a dead level, and would be untenable at high springs; so all stores must be carried at once to the camp, which is pitched on what was, last harvest, a huge jowaree-field. The soil near the shore consists of a sandy loam; but it becomes stony as the lower hills, from which the Waa emerges, are approached. Water is obtained close at hand, from wells in the bed of a river. The water from this source is very muddy, but sweet and drinkable after being allowed to settle. It is compared to the Indus water. The wells appear to have been filled from the rainflow. The name of this locality is Mulkutta. It is from thence that the people of Adulis get water; and there are some thousands of cattle on the coast, which are all watered there. Cattle is abundant, as also is game of all kinds, and it is reported that Colonel Mereweather shot an elephant within forty yards of the sea-shore. About sixteen miles inland an abundant supply of water has been discovered in the Waa river; a road has now been lined out to this locality, and a camp of the pioneer force has been established there. The country on the coast is compared to Sind along the Belooch frontier. There is much dry forage, which the people of Zoula declare to be luxuriant in the rains. The belt of malarious lowland between Zoula and Halai, the first Abyssinian town in the hills, is, in extent, only half that between Arkeko, opposite Musowah, and the hills. This is also the caravan route of the country, and by its adoption General Napier will retain, almost to the last, a discretionary power as to the ultimate destination of the force. The two drawbacks to it, however, are that its shortness involves steepness of ascent, and there are no villages till Dixan is reached on the sixth day's march. The use of gold and silver coinage is, it appears, confined to the wealthier inhabitants of the country; and the system of barter, which dates further back than the days when men of old “came into Egypt to buy corn,” is in vogue here. Big stones and little stones are the unique scale of weights and measures.

After all the expenditure that has been incurred in preparations for the expedition, the probable necessity for balloons appears to have been overlooked. In Abyssinia, balloons would be invaluable for the purposes of obtaining a general idea of the features of the country in the direction of the enemy, for discovering the enemy's position, or for looking into his camp.

WATER-TUBE FIRE GRATES.

TO THE EDITOR OF ENGINEERING.

SIR,—In your number of the 29th ult., page 513, I observe an illustration of a water-tube grate, designed by Mr. N. Mogensen, of Glasgow, and which is identical with one I designed for Messrs. Dodds and Son, Rotherham, and set to work at the Attercliff Steam Mill, Sheffield, about the year 1854, where it worked perfectly satisfactorily for some time. As my only object is to establish priority in what I consider a valuable design, I shall be glad to send you, or Mr. Mogensen, tracings of the boiler, &c., to which it was applied. The circulation of the water was exceedingly rapid, so much so that, soon after its first trial, some cotton waste, which had been left in the boiler, was found *very tightly* plugging up one of the tubes, which was speedily being burnt out, but was discovered in time to prevent any serious results. I believe that water-tube grates are yet in their infancy, and may be used with very great advantage, particularly in marine boilers, causing a considerable saving in fuel, besides preventing deposit and scale in the neighbourhood of the circulating-pipe connexions, where there is great difficulty of access, and where it is very essential the plates should be free from scale, on account of the intense heat to which they are there subjected.

A. STANSFIELD RAKE,

Consulting Engineer and Naval Architect.
Bank-buildings, Newcastle-on-Tyne, Dec. 6, 1867.

STEEL UNDER THE MICROSCOPE.—The little pocket microscopes for examining the crystalline structure of iron and steel recently mentioned in our pages are multiplying in this country with an astonishing rapidity. The neatest types of these lenses which have come under our notice are some very powerful achromatic combinations, inclosed in a small electro-plated cylindrical cap, designed and made by Mr. J. White, the well-known optician of Glasgow. Another very neat, although not achromatic, lens is sold by Messrs. Smith and Beck, of London. The price of such lenses of suitable size and power is from 14s. to 28s.; and their services, after a very short practice, are so important that no iron or steel masters, once accustomed to their use, likes to miss his pocket-microscope for an instant.

THE LANGLOAN IRONWORKS.

WE, a few weeks ago, described the Gartsherrie Ironworks as one of the most celebrated examples of iron-smelting works in Scotland, so far as the production of foundry pigs is concerned; and we have now selected the Langloan Ironworks, belonging to Mr. Robert Addie, for description, as a fair specimen of a well-managed set of blast-furnaces for the production of forge pig iron in the same district. The Langloan Ironworks consist of eight blast furnaces, of which five are at present in blast. The furnaces are all equal in size and proportions, and are placed in one row, advantage having been taken of a natural difference in levels of the ground for saving power in hoisting the raw materials to the bridges. The furnaces are 45 ft. high and 16 ft. in diameter at the boshes. The blast pressure is 3 lb., and the temperature about 800 degrees. The raw materials are of a greater variety than we have noticed in other Scotch ironworks. They consist principally of different kinds of claybands obtained from the neighbouring mines, the well-known rich blackbands of the same locality, and some red hematite from Cumberland. The fuel is a hard splint coal of a very superior character, drawn from mines belonging to Mr. Addie. The production of forge pigs requires a somewhat lower temperature in the furnace, and a smaller proportionate quantity of coal in the charges, than is the case with foundry iron. These two conditions have the effect of increasing that zone or space over the tuyeres in the furnace, which is filled with carbonic acid gas, the product of the complete combustion of carbon in front of the tuyeres. The carbonic acid gas, in its ascent, comes into contact with the iron reduced and carbonised in the zone above, and deprives the latter of a part of its carbon. The forge pigs made in Scotland are all grey, and contain more or less graphitic carbon according to their "number" or denomination. The combined carbon does not vary in a similar proportion in the different numbers, although, as a rule, the percentage is smaller in the irons of a lighter colour. Blackband ores are, as a rule, too rich for being used by themselves for making forge iron, and the claybands are therefore called into requisition as admixtures. The claybands are also less contaminated with phosphorus, and their admixture therefore considerably improves the quality of the iron as a raw material for the puddling process. The composition of the claybands, however, again calls for the addition of a third quality of ore, since their contents of alumina must be neutralised in forming a slag by an equivalent proportion of silica, which does not exist in the blackband. The Cumberland hematite is therefore added to the charge: it carries a sufficient quantity of silica, and is at the same time so rich in iron as not to interfere with the heat of the furnace by an overdose of slags. The claybands and blackbands are used in the calcined state, the former very often serving for the supply of fuel to both ores, a mixture of very bituminous blackband and of clayband being thrown together into a calcining heap, and ignited without any addition of other fuels. The hematite ore requires no calcination. Attempts have been repeatedly made at the Langloan Works, and in other ironworks in Scotland, to make forge pigs without any addition of blackbands, as such pigs would be of a superior quality compared with the present make, and probably even suitable for the Bessemer process. All these attempts, however, have failed as yet with raw coal as the fuel in the Scotch furnaces. The reason for this is the reduction of temperature. Each pound of slag formed in the furnace takes about one and a half times the amount of heat which one pound of iron requires by itself. In smelting rich blackbands there is scarcely one pound of slag produced per pound of iron made, while a mixture of claybands and hematites would make about twice that quantity of slag if smelted without addition of blackband ore. The demand for heat is therefore nearly three times as great in the one case as in the other. With coke as fuel this would cause no difficulty, since a sufficient supply of that fuel is all that is needed; raw coal, on the contrary, is itself a cooling agent in the upper part of the furnace, and does not become available for burning until it is completely coked. This coking process must be carried on at the expense of heat taken from the lower portions of the furnace, and it therefore follows that an over supply of coal will bring the temperature of the furnace down instead of raising it. The limits prescribed by the nature of the materials used in the present practice of iron-smelting in Scotland are therefore very narrow, and do not afford much scope for alterations. This, we have no doubt, is the principal reason for the fact that Scotch

blast-furnace practice has remained stationary for a very long time past, while iron-smelting in all other localities has been constantly progressing at a rapid pace.

The charges of ore and fuel are hoisted to the bridge of the furnaces at Langloan Ironworks by means of a water-tub counterbalance similar to those we described in our article on the Gartsherrie Works. The slags are of a neutral character, and they are used for road metalling in the neighbourhood of the works. The blowing-engines are of the make of Messrs. James Aitken and Co., of Glasgow, and are of a very superior finish and design. They have two vertical steam-cylinders, 50 in. diameter and 11 ft. stroke each, at the end of a cast-iron beam, the opposite end being occupied by the corresponding blowing-cylinders, 100 in. in diameter and 11 ft. stroke. The steam is supplied at a pressure of about 26 lb., by seven boilers of the Cornish type, each 5 ft. diameter and 30 ft. long. The boilers are fired with coal-slack, as are also the hot-blast stoves, which are of the usual pistol-pipe form. The make of iron averages 15 tons, and occasionally reaches 20 tons of pigs per furnace in twelve hours. Although forge iron is the principal article produced, there is always a certain proportion of foundry iron included in the total annual production of these works. The principal markets for the Langloan pig iron are Germany and the United States, where this brand commands a premium over the average market price of Scotch iron.

SULPHUR IN PIG IRON.

It has been maintained by several authorities that some of the sulphides and phosphides of iron remain liquid at a lower temperature than the great bulk of the iron itself, and that they are therefore likely to be collected near the centre of pigs or castings of considerable thickness. Mr. James Addie, of the Langloan Ironworks, has recently made some tests on that point which seem to confirm this theory. In breaking pigs of a certain class at his ironworks, a speck of peculiar appearance was frequently found in the centre of the fresh fracture caused by a different arrangement of the crystalline structure, but different from those specks which are occasionally seen in the centre of thick castings, and which are due to the shrinkage of the solidified material after its having set at the surface, and thereby fixed its outlines and size. Mr. Addie collected the contents of those central portions of the pigs by drilling the material out at those spots; and he obtained an analysis of this material, which, compared with the rest of the pigs from which it was drilled out, showed a large preponderance of sulphur in its combination. The sulphur specks do not run through the entire length of each pig, particularly not in the better qualities of iron, but they exist only in the central portion for a length of 2 or 3 in. Attention should be directed to this interesting point, and researches made with pigs and castings of different kinds of iron, in order to confirm this observation in a more general way, or if otherwise to find the conditions which are favourable or necessary for such a separation. We do not of course expect to free iron from its contents of sulphur by drilling out the central portion of each pig by itself; but to obtain certain information that sulphides will collect near the centre of a casting, and remain liquid there longer than the rest of the iron which contains a smaller proportion of sulphur, would in itself form an important step towards indicating some means of purifying iron from its most dangerous impurities.

THE FIVES-LILLE COMPANY.—This important French mechanical enterprise (late Parent, Schaken and Co.) has executed during the past year the bridge of the Place de l'Europe at Paris, and a great part of the ironwork at the Exhibition Building of 1867. The company is sharing with the house of Cail, a contract for the execution and equipment of the Russian Railway from Kiew to Balta, with branches. It is expected that this contract will result satisfactorily, but this will not be fully known until 1869. The profit of the year ending June 30, 1867, is stated at 84,425*l.*, which after, making statutory and special reserves, admitted of a dividend at the rate of 15 per cent. per annum. This dividend is, however, to be paid in obligations, in order that the floating capital of the company may be kept at as high a total as possible.

THE MEXICAN RAILWAY COMPANY.—A telegram, dated Havana, the 7th of December, was received in London last Tuesday by the Mexican Railway Company, with reference to the negotiations carried on between the Mexican Government and the company touching the terms of the new convention. It states, under date the 28th of November, from Mexico, that "the grant was signed yesterday (*i.e.*, 27th of November) on very favourable terms." The original concession on which the company was based was granted by Juarez, as president, on the 6th of April, 1861.

STEAM NAVIGATION IN 1803.

We reprint the following humorous lines, more from their historical interest than from any literary merit which they may possess.

THE STEAM BARGE, OR NAUTICAL NOVELTY.

(Written by WILLIAM MUIR, saddler in Kirkintilloch, March, 1803, on seeing the new invented-steamboat pass through the great canal, dragging two vessels behind it, fully loaded.)

WHEN first by labour Forth and Clyde
Were taught o'er Scotia's hills to ride
In a Canal, deep, lang, and wide,
Naebod' thocht
That wonders without win' or tide
Would o'er be wrocht.

To gar them true that boats would sail
Thro' fields o' Corn or beds o' Kail,
An' turn o'er Glens their rudder's tail,
Like weathercocks,
Was doctrine that wou'd needed bail
Wi' common folks.

They ca'd it nonsense, till at last
They saw boats travel east and wast,
Wi' sails an' steamers at their mast,
Syne, without jeering,
They were convinced the blustering blast
Was worth the hearing.

For mony a year, wi' little clatter,
An' naething said about the matter,
The horses haul'd them through the water
Frae Forth to Clyde,
Or the reverse, wi' weary splatter
And sweaty hide.

Then we believed, poor silly bodies,
Wha naething ken o' learned studies,
That horses' hoofs and hempen woodies
Be't still to draw them,
An' cursin' callins, clad in duddies,
To swear and ca' them.

But little think we what's in noddles
Whar science sits an' grapes an' guddles,
Syne darklins forth frae drumly puddles,
Brings thing to view
That the weak penetration fuddles,
O' me an' you.

For lately we hae seen a lighter,
An' in her doup a fanners flighter,
May bid boat-haulers a' gae dight her
Black sooty vent.
Then half a dozen horse she's wighter
By ten per cent.

Wi' something that the learned ca' steam,
That drives at heughs the walkin' beam
O' huge engines to draw coal seam
Or carry butches,
She in her breast swells sic a feum,
As hae few matches.

By it she through the water plashes,
An' out the stream behint her dashes,
At sic a rate baith frogs and fishes
Are forced to scud,
Like ducks and drakes among the rashes,
To shun the mud.

When first I saw her in a tether
Draw twa sloops after ane anither,
Regardless o' the win' an' weather
Athwart her bearin',
I thought frae h—ll she had come hithe
A-privateering.

An' that the pair she had in tow
Were prizes struck me, sae I vow;
I cried, when fixed to their prow
I saw her cable—
"In Satan's furnace now they'll low,
Among the rabble."

It was sae odd to see her pulling,
An' win' an' weather baith unwilling,
Yet d—ll ma care, she onward sculling,
Defied them baith,
As constant as a mill that's fullin'
Gude English clait.

Can e'er, thought I, a flame o' reek,
Or boiling water's cauldron smeeke,
Tho' it war keepit for a week,
Perform sic wonders,
As quite surprises maist the folks
O' gazing hunders?

But facts we canna well dispute them,
Altho' we little ken about them,
When prejudice inclines to doubt them,
Wi' a' her might,
Plain demonstration deep can root them,
An' set us right.

Or lang gae now, wi' whirlingigs,
An' steam engines will plough our rigs,
An' gang about on easy legs,
Wi' nought to pain us,
Bu' it in tethers, needies nags,
That used to hain us.

Braw news indeed for man and beast,
They'll then hae nought to do but rest,
An' on their former labours feast,
Wi' cheerfu' hearts,
When thus they see warm steam insist
To play their parts.

PROFESSIONAL JUDGMENT.

No other knowledge possessed by the engineer is so important as knowing what and when to believe. The practice of our profession is eminently progressive, and we are every day asked to act upon the result of some apparently successful experiment, as if it were a long-established fact. In some cases we can do so, but these are generally those of purely mechanical combinations. Thus a loom, of a new kind, which will work smoothly and well for even five minutes, may, if well made, be expected to work just as well for, perhaps, twenty years, or until it is worn out. Even here, however, there are other points than mere workability to be considered; for the loom may consume too much power, or require too much attendance. Then, too, the "if" thus interposed—the condition that the loom be well made—requires, generally, continued experience of its working before a decision can be given, although a thorough mechanic, long accustomed to looms, might pronounce beforehand whether the loom would go on working well or not, and merely from a close examination of its structure, proportions, and the finish of its wearing parts. It is not many years since a large pair of pumping-engines, made by a firm which, so far as reputability can go, should be one of the first among English engineers, was erected at Stoke Newington (we are not speaking of Simpson's excellent engines there), and had, after a few months, to be stopped and half reconstructed because of the total unfitness of their pump-valves, plunger-blocks, and holding-down bolts for their work. It is so with a great deal of machinery, and we might, if we chose, instance other examples, both by the same and other makers, showing that, like a babe of unsound constitution, a great deal of mechanism, which may appear to perfectly exercise its organic functions for a time, nevertheless contains the seeds of early decay. When we go from mechanism to works which only time can test, the judgment of the engineer must be exercised in a far higher degree and with far greater responsibility. Robert Stephenson, after some months of experimenting with plate-iron tubular bridge models, made up his mind to construct the most important railway bridge of all down to that time in a material which nearly all other engineers believed would crumble up like leather, and which many were sure would soon be eaten up with rust, like a neglected sander-bottom if often wetted, or a tin pail after long use. We have now many miles of these and other wrought-iron bridges, and if any one were now to announce that we as yet possessed no certain knowledge of such structures, and that they might break down any day from molecular deterioration, or from some other equally mysterious cause, it might appear difficult to gainsay him, until we reflected that any deterioration in such structures would probably be gradual, that it would thus be attended with a gradual sinking of the girders at the middle, and that, therefore, it would be discoverable in time. It is exactly in such cases that the engineer is called upon to exercise the very highest qualities of professional judgment, and that often upon points whereon less acute minds would conclude that there could be no room for difference of opinion. It is but a few years ago that concrete, as a material for foundations, was considered a new material by English engineers, very few of whom then knew that the Romans used concrete extensively, and that some of their works in this material have stood like marble for centuries. Who, not knowing this, could be sure of the permanence of concrete? It might, after a time, dissolve into gravel and sand, and many engineers, knowing little or nothing of chemistry or of the bearing of chemical evidence and chemical analogy, will not even yet listen to what so many experienced men are ready to tell them of the new concrete stone. "Show me an abbey built of it, *temp.* Edward I., and I will use it," they and certain architects would appear to be saying, and so we, suppose, Mr. Ransome, in order to convince their descendants, must endow an abbey, or some other edifice of the sort, and build it in his own stone. Then we have found, too, that certain building-stones, like that of which the Houses of Parliament were erected, decay rapidly in our modern towns, although presenting a fair exterior in their native quarry, and while, indeed, stone from the same beds, but quarried centuries ago, shows little traces of time in old churches and monasteries standing in the sweet air of our far-inland valleys.

As for foundations, too, it took time before engineers would believe in cylinders sunk by any process whatever, although brick walls had been thus employed in India for ages. Even when the one crucial test of a sunk cylinder, or screw pile, or Brunlees's disc pile,

was applied—that of loading it with so many hundred tons, and noting the rate, if any, of sinking—there were many to say that the cylinder or pile might yet be undermined, even if it stood on its trial like one resting upon primeval rock. We now know, however, that both cylinders and piles may be put down in quicksand, and yet stand as if resting on firm ground. Mr. Brunlees has not only carried long railway bridges over the sands of Morecombe Bay, but has spanned the shifting sands of the Solway Firth with a bridge a mile long, and is prepared to carry a ship railway upon piles, of the same kind, across the sands of the Isthmus of Suez.

It was the same with broken stone breakwaters. There were engineers who believed that all broken stone in a sea-way would be washed down as if it were so much shingle, and, indeed, there was so much in this belief that it is now found that nothing less than from 20 to 25 ton blocks of concrete can withstand the fury of the waves, and we now learn that Mr. Stoney, of the Ballast Board, Dublin, is contemplating the use of concrete blocks of 300 tons.

Once, we even believed in compound girders, *i.e.*, cast-iron beams bolted three together, end to end, and strapped up by wrought-iron tension-rods—the sort of girder that failed so disastrously over the Dee, at Chester, and which is yet in use on the Blackwall Railway and on one or two lines in Yorkshire. We learn by such failures what to avoid, but it does not follow that we are to avoid everything new, nor yet that we are to devote a whole lifetime in gaining an understanding of each new thing first exhibited to us in childhood or early manhood. The engineer who first employed cast-iron and afterwards wrought-iron piles in sea-water was, like the man who first swallowed the oyster, a very brave fellow indeed. The whole profession would have told him that it was unprecedented and irregular; perhaps that the action of sea-water on iron would turn the latter into plumbago in a week, and the instance of the guns of the Mary Rose—guns which laid ever so many hundreds of years at the bottom of the sea—is often cited to show how iron exposed to salt water may become as rotten as punk, and actually take fire when brought to the air!

And so in mechanical engineering; but we shall not here attempt to enumerate the hundred plans which have worked, despite professional and very profound predictions that they would *not*. There are, however, many points still unsettled. It is not yet quite certain that surface-condensation is an unmixed good. It saves coal for a time, but often knocks up the boilers before one-half their natural lives are over. And why is it, by the way, that all marine boilers, if pretty constantly worked, succumb in from five to seven years? And as to superheating, what a burning out of superheaters it is costing us! It would need some nice experiments, nicer than have perhaps yet been made, to determine exactly the loss or gain. As for high-pressure steam at sea, we have, all of us, so wished it might, could, or would do, that we have perhaps shown undue sympathy for it; but there is the naked fact before us that high steam has not yet answered the expectations so long ago, and so often since, formed respecting it. We have had high-pressure steam-boilers which promised well for a time, but which have signally failed at last. Even Harrison's cast-iron boiler, from its great strength, safety, and capability of being easily renewed in any part, appeared likely to attain a wide adoption, but it was found impossible at last to keep its joints uniformly tight. More lately we have had much speculation and somewhat encouraging experiments upon the water-jet propeller, but it has not yet shown any advantage over the screw. It might be said that it would be now premature to pronounce upon its future; but it is never premature to apply fixed principles to any question of engineering design, and here it appears that the water-jet is placed at a disadvantage in respect of the weight and friction of the water in the large passages which are requisite, and because, also, of the loss of efficiency in any centrifugal or other machinery employed to put the water, forming the jet, into motion. It might be said, too, that it is now premature to pronounce upon the Mont Cenis Railway, although we believe there are engineers who have already prematurely pronounced in its favour. The disadvantages, however, under which such a railway must work are very clear, and until we know that complication is preferable to simplicity, we shall, aided by what has lately come to our knowledge respecting the attempt to open this line, be prepared to hear of the complete abandonment of the system of the centre rail, and the adoption of a more rational mode

of obtaining additional adhesion, *viz.*, from the load itself; in other words, from the weight of the passengers and goods carried.

To such lengths may doubt and indecision be carried that, last year, an engineering newspaper, still professing to hold a place in the profession, proclaimed the insecurity or untrustworthiness of all iron bridges, and this from an untrue report that a gross load of somewhere between 40 and 50 tons had been denied a passage over Westminster-bridge. No denial of the kind had ever been made, and the bridge is open now, as it has always been since it was finished, for the passage of even greater loads. Still there are those professing to be engineers who are not yet sure whether iron bridges are safe, and who think we may have, after all, to go back to stone! The same journalist started the story that a fine arched steel bridge in Paris had already failed visibly, whereas the bridge, which has not been strengthened in any way, is still open for public traffic, and is known to be as strong now as it was when just completed.

The knowledge of the engineer is based not only upon natural perception, study, and observation, but, to a great extent, upon his capacity for recognising physical analogies. When told, for example, as a small section of our profession were lately told, that steel rails—which had worn out twenty-two times their number of iron rails, and which were yet tough and hard, breaking only under great strain—had become completely altered in constitution, because of "molecular deterioration," any competent engineer would perceive that if rails *were* thus altered in grain or fibre, so must be the steel tyres which run upon them, which bear identical pressure and blows, and every part of which comes down to the rails from forty to sixty millions of times during the average life of an engine tyre. The competent engineer would equally know that steel tyres remain tough to the last, and, when worn out, will bear drawing into fine wire.

Although not to be counted among moral offences, unreasoning unbelief is unprofessional, and in every way unworthy of the engineer. If he does not move somewhat in advance of the times, he should at least move with them; and nothing is more contemptible than the pursed-lipped, head-shaking, professional old woman, calling herself an engineer, but who is ever incapable of making up her own mind, except to mount that safe old staking-horse, precedent. Such as these, however, are happily but few in number now-a-days.

RUSSIAN ROADS IN CENTRAL ASIA.

THE present Viceroy of India began his rule on the 12th of January, 1864, and, should nothing occur to disturb the ordinary course of events, we may expect a continuance of that "masterly inactivity" policy which has so prominently marked Sir John Lawrence's rule, until the 12th of January, 1869. The five years embraced by those two periods will for ever mark an epoch in India's history, during which progress was at a comparative standstill. The only really great work of advance hitherto has been the establishment of an irrigation department; and the necessities of the empire, proved to demonstration by wide-spread famines and the remonstrances of the people of this country, rendered the further delay of such a measure practically impossible. It would appear, however, as if the great arteries of commerce, by which alone a country is made rich, were to be retarded and starved. Political interests are equally allowed to flag, and we are, consequently, yet uninformed of the probable intentions of the Russians in Central Asia, their objects in being there, and their ultimate intentions and designs. One mail brings us an assurance that the progress of Russia is rapidly advancing her armies towards the boundaries of our Indian empire, and speculation is rife as to whether she is directing her steps. Shortly afterwards, we learn from the Indian papers that China is the goal towards which our powerful neighbour is directing his attention. But, in the mean while, all is still in India—still, still as the grave; and the vice-regent of that vast empire makes no sign, and heeds not the advance which may sooner or later bring to our borders a powerful adversary, flushed with the success of easy victories over our neighbours, and aiming at no less than the expulsion of the British sway from India altogether.

But, be this as it may, would it be too great a sacrifice on the part of the Indian Government to encourage an increase in the extent of her railway communications, which would not only tend to strengthen our position there, but must also cause a development of trade, and help to utilise profitably some of that wealth which at present lies unemployed at home? But

whilst we are thus negligently relying upon our established position in India, our active neighbours are strengthening and consolidating their position by the very means of all others calculated to aid their future movements, and at the same time strengthen their position, and to aid the growth of their popularity amongst their vanquished foes. From the *Bombay Gazette* we learn that the construction of roads in Central Asia is one of the great undertakings which at present engage the attention of the Russians. Three roads, radiating from the head-quarters of the Russians, will be carried south-eastward, southward, and south-westward to Kashmere, Cabul, and Herat, thus establishing a communication between the Amoo and Syr rivers and Afghanistan, on the one hand, and India on the other. Should the Russians carry out these important works, a great benefit will no doubt thereby be conferred upon commerce; but, at the same time, the facilities which that Power will thus provide for the march of an army into Afghanistan, or even into North-Western India, will be vastly increased; and hence it becomes a question of no small importance, in what light we should view these advances. One thing, however, is evident from these undertakings—that the Russians are resolved to establish close communication with Afghanistan, and, in all likelihood, by the two roads to that region the army of Russians destined hereafter to conquer and occupy definitely the Afghan country will march down upon its two most important cities, Cabul and Herat. Whether the third road to Kashmeer will give passage to an invading Russian army into India is a question which more immediately concerns ourselves. That such is one of the objects of the Russians may safely be concluded, at the same time that the success of such an attempt fortunately rests not wholly with them. By all means let the Russians construct their roads, even down to our frontiers; happen what may hereafter, they will be a gain for commerce and general civilisation; and it is satisfactory to think that the same road which brings down the Russians to us may carry our Sepoys into the heart of the Russian settlements in Central Asia, should we find it to our interest to look up our Russian friends in that quarter of the world. In the mean time, however, it behoves us to be prepared for possible eventualities, and, by the construction of either first-class roads or railways to our north-western frontiers, to be prepared to push forward our armies for the defence of our possessions so soon as the first reliable note of alarm shall have been sounded.

THE NEW SOUTH WALES RAILWAYS.

TO THE EDITOR OF ENGINEERING.

SIR,—In your notice (November 22, No. 99) of the long eight-wheel carriages for the New South Wales railways, you say that "one of those carriages has been fitted with Mr. W. Bridges Adams's radial axle-boxes," apparently unaware that the whole of the carriages are on my radial system, the value of which was recognised by Mr. Fowler. The first long eight-wheel carriages on the Metropolitan were constructed with a short four-wheel under-frame at each end, the end wheels being 5 ft. 9 in. apart, and the extreme wheel base 28 ft., four side-springs being fixed to the axle-boxes of each frame, and the upper frames suspended from them by shackles with centres 5 in. in length, placed at an angle, permitting forward, backward, and lateral movement of the axles, as well as a compound diagonal movement, to the small extent allowed by the length of the shackles and the axle-guards.

I was quite certain that the action could not be favourable, from my own past experience of my bowspring years back, which permitted a far greater movement, viz., 4½ in. laterally to each side and 2½ in. fore and aft. There were eight wheels; extreme base 30 ft., equally divided. For straight lines nothing could be more perfect than their action—steady, non-oscillating, and free from jarring; but on curves the tendency was for the axles to recoil by the pressure of the wheel flanges against the outer rail, placing the axles in lines abnormal to the radii of the curves, and thereby inducing grinding, friction, and surplus resistance. The extreme length of these carriages was 40 ft.

I believe you were yourself present at experiments of haulage on the Metropolitan in the year 1864, and remarked the great resistance. On reading a paper at the Society of Arts in December, 1864, I had some conversation with Mr. Burnett, who was present, and I pointed out the material source of abnormal resistance on the recoiling of the axles in the wrong direction, and the necessity of giving them guidance independently of the wheel-flanges. I did not urge the adoption of radial axle-boxes, because they would not permit the amount of lateral and radial movement required in so long a carriage; but in December, 1865, Mr. Burnett furnished me with a tracing of the frames, in order to apply to it the radial guide movement. This was effected by a quadrant iron fixed to the under-frame, and keeping the two axles parallel together. This quadrant was pivoted to the upper frame, immediately above the inner axle, while the radius passed between two circular plates in front attached to the upper frame. The springs are fitted with swinging shackles, 18 in. long, from which the frame was supported by deep scroll irons. Thus the wheels and axles were free

to move in any required direction to a far greater extent than with the original short shackles, but wholly controlled and guided in their movement by the quadrant guides keeping them true to all curves. The advantages gained were the absence of flange-friction on the leading wheels, with true guidance of the flanges to the nuts of the inner wheels, preventing all side swing, and with perfect ease of movement without frictional slides, yielding freely on curves, and the pendulous action restoring the axles to a rectangular position on the straight line; and the mode of conversion from the unguided to the guided system was simple and cheap, while it would permit their long carriages to pass freely round curves of two chains radius. There was one slight mechanical objection common to all existing railway-carriages—the permanent parallelism of the two axles at each end; but with a base of 5 ft. 9 in. this was of very little importance, as compared with the 12 ft. and 16 ft. bases now in common use, and which might be wholly obviated by the use of tyres sliding on the wheels.

Mr. Burnett did not use this particular plan, but applied radial axle-boxes to the end wheels. This made true movement, but insufficient in amount for the length of base, leaving 16 ft. rigid base for the inner wheels. He then resorted to radial frames for the end wheels connected to the axle-boxes, using long swinging shackles to the external ends of the springs, which is another of my plans, pivoting a guide frame which does not take a load, but merely guides the wheels without interfering with the spring action on swinging shackles. Mr. Burnett was, I believe, the first to adopt this plan, which is no doubt very effective. I think there is a difference in the Metropolitan carriages and those of the New South Wales, the latter having the wheel spans equally divided, the inner wheels on the latter being 14 ft. apart, the former 16 ft., which will make more difference in friction.

It is now some thirty years that I have been trying to persuade railway authorities that the longer the carriages, the safer and steadier they would run, and that by the process of radiating the axles they would run on any curves, independent of length. There are certain disadvantages in great length as to commercial working, but it is now perfectly practicable to construct four-wheel carriages with long 16 ft. bases and radial axles to roll freely round curves of one chain radius, steady under all circumstances, and free from flange friction, every carriage being provided with a self-acting brake-block to each wheel, without noise or jarring, and coming into instant action on the breaking of a coupling causing the division of a train on an incline. It is obvious that wear, tear, and resistance consist in flange and tread friction, and that a very heavy percentage of saving would ensue by converting sliding movement into rolling movement.

In providing for the movement of the swinging shackles, it is essential for durability that the bearing surfaces should be balls and sockets. The simple links of round rod, bearing only at a point, are not enough, as they cut in; the experience of this in the old stage coaches led their owners to resort to hardened shackles of steel, and they were liable to breakage. The ball and socket is simpler, quite as cheap, and is, moreover, durable, allowing the use of lubricated washers for every movement.

In long carriages, intended for exportation by sea, it is desirable to build them in two parts, to bolt together, for easy shipment. My former bowspring carriages were so constructed, but I had not provided for radial guidance. The drawings of these carriages will be found in Mr. Clark's "Railway Machinery."

I am, Sir, yours faithfully,
W. BRIDGES ADAMS.

NOTES FROM INDIA.

Bengal.—The all-absorbing topic in Calcutta is of course the cyclone of 1st November last, and its disastrous consequences. In Calcutta and its suburbs the loss is more accurately known at present than it is elsewhere. In the city itself 109 deaths have been recorded, 101 brick-built houses destroyed, and 2338 tiled and thatched huts levelled with the ground. In the suburbs the loss of life is estimated at 285, and 62 brick-built houses, 1745 tiled huts, and 25,148 thatched huts have been destroyed. On the river 622 lives have been lost. In addition to the above, there have also been lost 2 ferry-steamers, 67 cargo-boats, 15 Madras sloops, 84 dinghies, 82 native boats, and 336 up-country boats. The grand total of lives ascertained to have been lost is therefore 1016; of brick-built houses destroyed, 163; and of tiled and thatched huts, 29,231. Of the larger shipping in the river only some twenty-six ships have escaped uninjured; and three have sustained serious damage, one of them being a complete wreck. Telegraphic communication around Calcutta has ceased. Messages intended for the north-west are obliged to be sent up to Burdwan by train, and thence despatched. Even with Saugor, and on the eastern side, all communication has ceased, and the cessation of telegraphic communication with Saugor has given rise to considerable anxiety. At Port Canning the greater part of the ballast of the rail is carried away as far as Bursa, three miles; the station and a goods shed are blown down, only the front cylinders of the railway jetty being left. Two wooden jetties are gone, and the sea has broken through into the dock by the neglected part of the banks of the Bydiadhurree. At least one-half of the rice crops in the districts visited by the cyclone are stated to have been destroyed. The damage done by the recent inundations to the Eastern Bengal Railway have now been made good, and trains run through again as usual. It is reported that the Secretary of State has called upon the Governments of Calcutta, Madras, and Bombay to submit plans for buildings to be erected for the conversion of Enfield rifles into breech-loaders on the Snider principle, and for the manufacture of Boxer cartridges. It is now thought that it would be better to supply breech-loading rifles from England than to attempt to convert the arms in India, and it has been proposed that for the future the arm shall be gradually introduced into the three Presidencies by troops proceeding to India, who will take out their Snider

rifles with them. Certain officers now on furlough have been placed under instruction at Woolwich to learn the process of manufacturing ammunition for Snider rifles.

North-Western Provinces.—The Lieutenant-Governor has taken steps recently for establishing museums throughout the country, in which collections of books, drawings, photographs, and other objects will be made available for public use. A central museum is to be established at Allahabad, with sub-committees for the departments of science and art. The object in view is the improvement of native industrial art, by enabling artisans to compare their own workmanship and designs with those of European workmen. The museums are to include collections illustrative of the natural history, products, and art remains of the country.

Cashmere.—Paper of a superior quality, and of a consistency approaching to English paper, is now being manufactured in Cashmere. A report is current that the Maharajah has prohibited the use of all other paper within his territory, and it is thought likely that he has granted a patent to the manufacturer for a term of years, no doubt for a handsome consideration.

Central Provinces.—During his examination of the rocks around Nagpore, Mr. Blandford, of the Geological Survey, reported very unfavourably of the prospect of finding any coal near Nagpore itself. More recent researches have, however, led to the discovery that Mr. Blandford had made a mistake, and Dr. Oldham at once pointed out that the rocks belonged to a more recent series, which accounted for the absence of shale and slaty sandstone. The exact character of the coal has not been satisfactorily ascertained. The investigations of the survey are being proceeded with rapidly southwards from Nagpore and the Godavary, and northwards from Madras, Cuddapah, and Kurnool, and in a few years more a geological section will be completed from Thibet to the Gulf of Manaar.

Madras.—It is expected that the whole of the Tamber-cherry Ghaut, in Wynnad, will shortly be opened for cart traffic, and, in order to expedite the works, an additional company of sappers and miners is about to be employed on them.

Bombay.—The Municipal Commissioner's budget for 1868 estimates the expenditure out of current revenue, exclusive of interest on a proposed new loan, at 31,77,913 rupees, and the income at 33,15,618 rupees, thus showing a surplus of 1,37,705 rupees. The Municipal Fund is debtor to the Drainage Fund to the extent of 16 lacs; the commissioner proposes to raise a loan of 14½ lacs, at 6 per cent., 10 lacs of which are to be debited to the Drainage Fund, and expended during the year on the proposed works. The committee appointed by the Government to inquire into the question of the proposed docks for Bombay has, by the casting vote of the chairman, reported in favour of docks. The doubling of the Great India Peninsula Railway line between Egutpoora and Nassick is expected to be finished by the end of the present year. Plans and sections of the portion of the Necmunch and Delhi extension of the Bombay, Baroda, and Central India Railway, from Sunganeer to Nusseerabad, have been completed, as has also the survey to Jeypore, a section of which is about to be started, and another party is working towards Agra. The extension of the line to the river Sabarmuttee, at Ahmedabad, a distance of 2½ miles, will shortly be commenced, tenders having been invited for the work. The railway bridge over this river, which was designed by Mr. A. W. Forde, formerly chief engineer of the Bombay and Baroda Railway, has been let to that gentleman for 4½ lacs of rupees. The design is said to be a very handsome one. Mr. Walton, the acting cotton commissioner of Bombay, estimates the area under cotton in the presidency at 1,891,870 acres against 1,973,181 actually cultivated last year. The shipments of this article from Kurrachee in September last consisted of 143,696 lb., valued at 5055½. The *Sind News* complains that after upwards of thirty years' experience of the Indus, no engineer has yet been found who could make a steam-vessel capable of running up this river. Had the Americans or French possessed the Indus for even a portion of the time England has had it, a different result would have been the consequence, and instead of vessels leaving Kotree, as they do now, at rare intervals, a regular fleet would have been running bi-weekly, or perhaps daily; the whole of the trade from the Punjab and the countries beyond would have been brought down the Indus, freshwater native craft would have disappeared, and the port of Kurrachee would have been far different to what it is.

Ceylon.—The north-east monsoon has severely tested the works on the railway incline. Hitherto, fortunately, no accident of any moment has occurred beyond the delays occasioned by landslips, but it has been thought necessary, in view of the risk attendant in passing over this portion during the present rainy season, to discontinue the only night train there was. The railway is not, it appears, working with that regularity and precision for which the iron horse is generally so distinguished.

China.—From the *Overland China Mail* we learn that the Grand Canal, which has been gradually drying up since 1867, has now become utterly impassable—vessels drawing a few inches only being unable to find water to float them. A new masonic hall was opened at Shanghai, on September 25th, by the Provincial Grand Master of China. The colony's supply of gas was cut off in a somewhat novel manner on the evening of September 29th, by the break and burial of about fifty or a hundred yards of the main pipe. Excavations from the Praya, landwards, had been going on for some time on the Battery road, about halfway between the West Point Nullah and the gasworks, and having approached too near to the main, about fifty tons of the hill suddenly gave way with a crash, which carried with it a large portion of the main pipe. Fortunately, no one happened at the time to be under the hill, and there was consequently no loss of life. The gas was turned off at the works so soon as the accident was discovered, and consequently the street lamps and consumers' meters on the lower roads were very soon exhausted, considerably darkening the town. The damage has since been repaired.



*James
i. Allen*