

RECENT PATENTS.

The following specifications of completed patents are all dated within the year 1867; and that year should be given in ordering them, at the annexed prices, from the Great Seal Patent Office, Chancery-lane.

(No. 77, 1s. 8d.) Michael Henry, of 68, Fleet-street, patents, as the agent of François Coignet, of 33, Boulevard St. Martin, Paris, an apparatus for manufacturing beton, and various methods of applying that material to structural purposes. According to this patent, the beton is made by the direct mixture of damp sand or damp gravel with powdered lime, very little water being added. The materials are triturated in a long horizontal chamber, through which pass two shafts, which are connected by gearing so that they revolve together, and which are furnished with arms disposed spirally. M. Coignet has had great experience in the use of beton, or concrete, and his specification contains much that will be interesting to those employing that material.

(No. 79, 1s. 6d.) Henry Buss, of 56, High-street, Shoreditch, patents a system of constructing piers, breakwaters, &c., by building iron caissons of forms similar to that of portions of the proposed structure, and then floating them to their places, after which they are to be sunk and filled in with stones and concrete. It is proposed to build these caissons the full width of the pier or breakwater, and in some cases 1000 feet long; and after they have been sunk they are to be secured by driving piles through their bottoms, and by bolting the adjacent sections to each other. We fear that, unless the caissons were very elaborately and consequently expensively stayed, they would never stand the racking strains to which they would be subjected by resting on uneven bearings; and altogether the scheme is one of, to say the least of it, doubtful practicability.

(No. 80, 1s.) John Tomlinson, of Pooley's Park, City-road, Holme, Manchester, patents improvements in the construction of ovens and scrap furnaces. In the latter, the firegrate is placed in the usual position, and the flame from it, after passing over a hollow perforated bridge, is led under a pair of hanging bridges which deflect it downwards upon the hearth.

(No. 83, 10d.) Charles de Bergue, of 10, Strand, patents a tool for use in packing permanent ways. This tool—which is likely in many cases to be a convenient substitute for the ordinary single-lever bar—consists, in one form, of a cast-iron bedplate which can be slipped under the rail that is to be raised, this bedplate having a lever laid in a recess on its upper side. One end of the lever is hinged to the bedplate, and the other end can be raised by a screw so as to lift the rail, which will bear upon a part of the lever formed to receive it. In another form of the apparatus a bell-crank lever is employed.

(No. 85, 8d.) Henry Duncan Preston Cunningham, of Bury, near Gosport, patents various forms of tongs or lifters for raising shot, and also carriages for transporting heavy shot or shells.

(No. 88, 4d.) Robert Mushet, of Cheltenham, patents an improvement in the manufacture of cast steel. In making cast steel by the ordinary process of melting, it is customary to add to the charge of each melting-pot a few ounces of peroxide of manganese as a flux; and for this peroxide of manganese Mr. Mushet proposes to substitute chromate of iron, oxide of chrome, or an artificial mixture of chrome oxide and oxide of iron. By preference, however, he uses natural chromate of iron on account of its cheapness. The chromate of iron is prepared by pulverising it, and it is introduced into the melting-pot with the charge of steel or steel-producing materials. The proportions may be varied according to circumstances; but Mr. Mushet mentions the three following mixtures in his specification: No. 1, cast steel ingot tops or steel bar ends, 40 lb.; chromate of iron, 6 oz. No. 2, spring-steel scrap, 38 lb.; spiegeleisen, 2 lb. or 3 lb.; chromate of iron, 6 oz. No. 3, hard converted bars, 40 lb.; chromate of iron, 6 oz. After melting, the steel is poured in the usual manner.

(No. 99, 1s.) William Clark, of 53, Chancery-lane, patents, as the agent of George Ross, of Newport, U.S., improvements in pipe moulding and in casting apparatus, these improvements consisting in so arranging the moulding and casting pits, &c., that the operations of preparing, drying, and filling the moulds can be carried on without interfering with each other. A form of sprinkler for coating the interior of the moulds with blackwash is also included in the patent.

(No. 107, 8d.) Austen Hill, of Leicester, patents a method of applying fixed cutters to the finger-bar of reaping and mowing machines. According to this plan, the cutters are made so that their upper surfaces

are flush with the upper surface of the finger-bar, whilst their stems are rebated, so that they come underneath the finger-bar, and between it and the stems of the fingers. The cutters are also recessed within the stems of the fingers, and they are secured by bolts passing through their stems and through holes in the finger-bar.

(No. 115, 8d.) John Davies, of 24, Ludgate-hill, and Arthur Helwig, of 73, Old Kent-road, patent forms of permanent way. The patentees propose to make double-headed rails with oblique webs, the rail being thus of I section, and to carry these rails by bolting them to one-sided chairs, the tops of which bear against the under side of one flange of the upper heads of the rails. Such a system is open to very many objections.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of the Glasgow Pig Iron Market.—During the last week the pig iron market has occasionally been firm and brisk, but the extent of sales effected has not been very great. The prices have varied between 53s. 7½d. cash, and 53s. 9d. at a month and 54s. 5d. at a month, and 54s. 3d. cash. On Monday last 5000 tons changed hands at 54s. 1½d. cash. Including both the foreign and coastwise traffic, the shipments of pig iron from Glasgow during the week ending September 14th amounted to 5487 tons; the shipments from Ardrossan for the week ending September 12th were 4548 tons; and from the port of Greenock, for last week, 1300 tons, 1000 of which was for New York. The total shipments of coal from Greenock during the week amounted to 3549 tons.

Proposed New Association of Operative Boiler-Makers and Iron Shipbuilders in Scotland.—Owing to the revelations recently made at Sheffield and Manchester, through the Trades Union Commission of Inquiry, very few persons are now ready to affirm that trades' unions are an unmixed good. From two meetings of artisans and operatives that have just been held in Glasgow and Greenock, it seems that a number of the working classes are not wholly satisfied themselves with these institutions. Efforts are being made at present, chiefly by Mr. Wm. Swan, an Englishman resident in Glasgow, and formerly a member of the old national association operating from London, to establish such an association as is named above, in which it is proposed to conserve what is good in trades' unions, and reject what is evil. Mr. Swan proposes to dispense with strikes, and to make the trade-union really a provident society, which should afford assistance to members out of employment, in sickness, old age, suffering from accidents, bereavements, or death. Hitherto, these efforts have not been attended with much success, as many of Mr. Swan's fellow-operatives look upon them with a certain degree of suspicion.

The China Tea Race—the Greenock Clipper, Taeping, against the Winner.—The excitement in reference to this year's great ship race has perhaps been greater this season than in any former one. The first ship of the China tea fleet having arrived in the Downs on Saturday last from Foo-chow-foo, and that ship being the Taeping, there is a little excuse for the outburst of enthusiasm which has been manifested in Greenock and in Glasgow in consequence. The Taeping is a Greenock-built clipper of 767 tons register, the builders being Messrs. Robert Steele and Company, and the owners being Messrs. Koller and Company, of Glasgow. The time taken to reach the London Docks, where she got berthed at 3 o'clock on the morning of Sunday last, was 101 days, the distance being about 14,600 miles. She brings 1,139,961 lb. new season's tea. Last year's race was also won by the Taeping, the time then taken being 97 days. Her voyage out, however, was accomplished in even less time, namely, 85 days. The home voyage in 1865 took 115 days. The premium gained by the Taeping last year was 10s. per ton; this year there is no premium, but large sums of money have been made on the race by way of bets. The Maitland, built by Mr. Pile, of Sunderland, in 1865, and the Serica, built also by Messrs. Steele and Company, left Foo-chow-foo before the Taeping.

Cheap Traffic between Glasgow and Belfast.—At present there is a sort of war to the knife going on between the two companies which compete for the traffic between this city and Belfast, a war that will not tell well for the interests of the shareholders who are concerned in the matter. Messrs. G. & J. Burns have several magnificent and well-appointed mail-steamer, running to and from Belfast, via Greenock, and there is another company carrying goods and passengers, via Ardrossan, in conjunction with the Glasgow and South-Western Railway. The strife has now reached such a point that Messrs. Burns are taking steerage passengers at one shilling per head, including the railway ride of 22 miles between Glasgow and Greenock; while by the Ardrossan route the steerage and third-class railway fare is only sixpence, and the cabin and first-class railway fare is reduced to five shillings, and to eight shillings for a return, available for one month. It becomes a nice question for the Glasgow and South-Western Railway authorities to calculate what will be their share of the sixpenny fare.

Dingwall and Skye Railway.—The landowners interested in the scheme for effecting a railway connexion between Skye and the Highland line, so ably described by Mr. Joseph Mitchell, at the British Association meeting at Dundee, has just been held, under the presidency of Lord Middleton; Vice-Chancellor Sir John Stuart and Mr. Matheson, M.P., being amongst those who were present. The last-named gentleman subscribes for 24,000l. worth of stock, and also takes stock for 13 miles of land through which it is proposed to carry the line. It is expected that the projectors of this line of railway will go to Parliament for powers in the ensuing session. Should the project be carried out, there is every probability that it would materially affect the condition of the North-west Highlands and Islands, improving the value of the property, and developing the natural resources of the country.

Inspectorship of Weights and Measures.—At a meeting of

the magistrates held yesterday, an appointment was made for this office by the election of Mr. Arthur Herriot, scale and beam weighing-machine maker. This is certainly "the right man for the right place," if twenty-five years of experience in the actual manufacture of weighing-machines should count for anything. It was this gentleman's weighing-machines which were so highly commended at the recent show held by the Highland and Agricultural Society, by Professor Rankine and his fellow-judges in the implement and machinery department.

The Proposed Harbour Improvements at Aberdeen.—The Aberdeen Harbour Commissioners have recently decided that the professional advice of Mr. Hawkshaw, C.E., and Mr. Abernethy, C.E., London, should be obtained before finally approving of the new works suggested by their own engineer, Mr. W. Dyce Cay, C.E., and of which mention was made in a former letter. These gentlemen have agreed to visit the "granite city" on an early day.

Adoption of Messrs. Bell and Miller's Report on the River Ribble.—The report prepared by Messrs. Bell and Miller, the eminent civil engineers of this city, has been adopted by the corporation of Preston. It is proposed to expend a sum of 150,000l. on improvements of the river Ribble, so as to render it navigable for vessels of a large size, and in the construction of wet docks.

The Proposed Public Graving Dock at Glasgow.—There is a great degree of probability that the Clyde Trustees will not be called upon to spend their vote of 60,000l., recently spoken of, in constructing a new graving dock as proposed. The graving dock, slip dock, and the shipbuilding yard of Messrs. Tod and Macgregor are likely to be in the market soon for sale. The site is all that could be desired, and embraces ground extending to about twenty acres. The ground occupied by the shipbuilding alone would suffice for the construction of two graving docks of the largest class, as well as slip docks, in addition to the graving and slip docks at present existing. It is not said why this old and eminent shipbuilding firm is giving up business, but the probability is that its members have fared so well in times past that they do not care to continue to work in the present dull season, or have the responsibility of so much valuable property in their hands while it is practically doing nothing, and bringing no return.

A Greenock Shipowner.—On Tuesday of last week no fewer than ten full-rigged ships, of the aggregate tonnage of 7300 tons, belonging to Mr. John Kerr, shipowner, Greenock, were loading and discharging in the harbours of that port. These only form part of Mr. Kerr's fleet. During the whole history of shipping on the Clyde, no individual shipowner ever had such an extensive fleet of vessels in the harbours of the port at one time. Most of the vessels have recently arrived from the West Indies, laden with sugar.

New Works, Extensions, &c., on the Glasgow and South-Western Railway.—The whole of the branch line between Ayr and Mauchline is now in course of construction, and the works of the short branch from the main line between Paisley and Johnstone, to the Bridge of Weir Railway, have been contracted for, and this branch and the works on the Bridge of Weir line necessary for the accommodation of the Greenock traffic will be completed in time for the opening of the Greenock and Ayrshire Railway next year. The directors some time ago arranged, in the interest of the company, to acquire a portion of the capital of the Glasgow, Paisley, and Johnstone Canal, and the result has been that, while the public continue to have the advantage of conveyance both by railway and canal, a saving of expense has been effected. The directors will take a fitting opportunity of applying for Parliamentary authority to carry out this arrangement, which they believe to be very beneficial to the company.

Important Trials under the New Masters' and Servants' Act.—A large number of the miners in the Hurlford and Kilmarnock district left their work about a week ago to do a little in the "striking" line. Three of them were brought before the sheriff, under the provisions of the new Act named above, for having left their work without having given, in terms of their agreement, 14 days' warning. The sheriff found the charges proven, but stated that, as these cases were the first that had come before him under the new Act, he should only impose in each case a nominal fine of 10s., with 50s. expenses, with the alternative of imprisonment if not paid within eight days.

THE CONSUMPTION OF FUEL.

TO THE EDITOR OF ENGINEERING.

SIR,—I notice that Mr. Paterson, in his paper on the "Consumption of Fuel," read before the British Association at Dundee, compares his calculated rate at which air passes through the firegrate with that of the escaping products as given by Dr. Ure in 1863, and states that the former shows much lower than ought to obtain for proper combustion.

Now, though I do not think the two results, depending as they probably do on a variety of dissimilar conditions, can be properly compared, yet I do think the theoretical rate of the entering air in Mr. Paterson's examples ought to be higher, and it appears to me that an error has crept into his calculations, as given in rule No. 7, which will account for the low rate.

After dividing the cubic feet of air required, by the time in seconds required for evaporation, the author proceeds to multiply and divide by the side of the squares of firegrate and air-passages respectively; but it seems to me that the proportion of the rates the air passes through the fuel area and firegrate area should be as the areas themselves, and not as the sides of the squares—that is to say, the fuel area should be to the firegrate area as the rate through the first is to that required.

Thus, in the example of the Newcastle Hartley, rule No. 7, the figures would stand as follows:

$$\frac{9619.2 \times 14790.505}{285.148}$$

$$\frac{35.568 \times 438.272476}{12.322} = \text{rate required.}$$

I shall hope to be corrected if I am wrong, but I think the quicker rate is more likely to be the true one; and if so, it approaches nearer to what is the actual fact in practice.

I am, Sir, yours obediently,

CHAS. J. SPENCER.

Steam Boiler Works, Stratford, E.,
September 18, 1867.

A TUNNEL UNDER THE MERSEY.

At the last meeting of the Mersey Docks and Harbour Board, the following communication from Mr. John Hawkshaw, C.E., was read:

PROPOSED LIVERPOOL, BOOTLE, AND BIRKENHEAD RAILWAYS.

To the Chairman and Members of the Mersey Docks and Harbour Board.

Gentlemen,—The discussions at your board, and the Parliamentary proceedings during the late few years, all tend to show the necessity of a perfect and complete communication between the docks on the Cheshire side of the Mersey and those on the Liverpool side, and also that a railway connexion with the railways on the Lancashire side is necessary to bring into profitable operation the five millions of money expended on the docks at Birkenhead.

The evidence given by the members of your board before the committee of the House of Lords on the scheme called "The Birkenhead and Liverpool Railways," in the session of 1865 was in favour of a tunnel under the Mersey. It is evident that a bridge or viaduct would interfere with the free navigation of the river, whilst, on the other hand, the sandstone rock which underlies the bed of the river affords facilities for the construction of a tunnel.

The purpose of this communication is to bring before you the best and most practical mode of carrying out this object, and I have no hesitation in recommending the construction of a main line with a tunnel under the river, in the direction marked on the accompanying ordnance map, the preliminary surveys and sections of which have been prepared.

It will be seen from this map that it is proposed to cross the Mersey between New Brighton and Bootle, that being the best point for connecting the dock lines on each side of the river, and the rock there offering peculiar facilities for the construction of the works, and, above all, for forming convenient connexions with existing railways. The course of the main line would commence on the Cheshire side by a junction with the dock lines and railways at the north end of the Great Float, so as to communicate with both sides of the float, and, passing under New Brighton and the river Mersey, to the north end of the proposed new Bootle docks, would connect itself with the dock lines near to or opposite the Strand Promenade. This line would, of course, be principally in tunnel under the river and the rock at New Brighton, and although the river is wider here than at the south end, the total amount of tunnelling on the whole scheme will be less than on any other practicable project that I have seen.

A branch from near Rimrose Bridge would proceed alongside the Aintree and Bootle branch of the Lancashire and Yorkshire Railway, forming a connexion with it near to Orrell. And an extension by Walton-on-the-Hill would form a junction with the newly-constructed Bootle branch of the London and North-western Railway. There would also be a fork from Rimrose Bridge to form a junction in the direction of Liverpool with the Southport Railway near Marsh-lane station.

On the Cheshire side, another short connecting link is proposed to the Hoylake Railway.

This is a brief description of the direction of the proposed lines, and I think that in no other way can the objects be obtained at so small an expenditure.

A comparison, for instance, between this scheme and that called the "Birkenhead and Liverpool Railways," brought before Parliament in the session of 1866 gives the following results:

Proposed Lines.		Birkenhead and Liverpool Railways.	
Total length of lines, 9½ miles	14½ miles.	Length of tunnelling, 4,800 lineal yards	12,480 lineal yards.
Estimated cost, say, 785,000l.	2,464,136l.		

But as the "Birkenhead and Liverpool Railways" would have to pass through valuable property and buildings on both sides of the Mersey, the estimate must be uncertain; whilst the lines now proposed may be constructed without disturbing a single building or interfering with any valuable commercial property, and it will be perceived that they have the great advantage of direct communication with the most important lines in the district, whilst the other lines can readily obtain access to them.

But in a work of this nature it is prudent to make large allowances for contingencies; and even assuming that the estimates were exceeded by 20 per cent., the cost would still be under one million of money; and the large amount of traffic, and the important interests it will serve, would justify this expenditure.

It is clear that the main line which makes the connexion between the docks on the two sides of the river, and in fact unites together the two disconnected portions of the dock estate, would involve a considerable proportion of the expenditure, and the project would require assistance from you in combination with the different railway companies who are interested in securing the construction of these lines; and as the interest of the dock trust is so largely concerned, it has been considered desirable to draw your attention, at this early stage, to the fact that a very complete system of railways, embracing connexions between the docks and lines on both sides of the river, can be constructed at a cost of probably one-third of any practicable scheme that has been previously proposed.

Mr. Perring expects to have the plans and sections completed in a few days, and will then be ready to submit them to your consideration.—I am, gentlemen, your obedient servant,

JOHN HAWKSHAW.

33, Great George-street, Westminster, S.W.,
August 31, 1867.

The chairman said the communication would be referred to the works' committee, though he did not know that the board could take any part in forwarding the scheme proposed.

THE CIVIL AND MECHANICAL ENGINEERS' SOCIETY.—The Civil and Mechanical Engineers' Society will visit the Abbey Mills pumping-station of the Main Drainage Works on Saturday, the 27th inst., assembling at Stratford-bridge Station at three o'clock.

COAL-CUTTING MACHINES.

TO THE EDITOR OF ENGINEERING.

SIR,—A few days ago I had the opportunity of seeing some coal-cutting machinery at work, and the process struck me very forcibly as one eminently practical and successful, and as one, which, although not sufficiently encouraged by colliery owners of the present day, cannot fail gradually to force itself upon their attention, as a system likely to supersede the present mode of working, cheapen the cost of getting, relieve the miner of the most burdensome portion of his toil, while at the same time it will open out the means of perfecting the system of ventilation in our coal mines.

Seeing, therefore, that the subject is, or ought to be, of great interest to a considerable number of your readers, I have not hesitated to send you the following particulars.

The pit was at West Ardsley, near Leeds, belonging to the "West Yorkshire Iron and Coal Company," and the machines I saw at work were Firth and Donisthorpe's patent, both pick-action and straight action, worked by compressed air. The shaft was 160 yards deep, and the distance altogether from the compressing engine to the machines at work was about 1400 yards.

Down the shaft the motive air was carried in a 4 in. cast-iron pipe, but below, the rest of the distance, in only a 2½ inch pipe. The engine was compressing to about 50 lb. per square inch, and the pressure at the machines when at work was 43 to 44 lb., showing, although carried so long a distance in so small a pipe, a comparatively small loss of pressure.

Each machine was working along a 50-yard bank, and supplied with air from a 1½ in. elastic pipe.

The pick machine was inspected first. It was working very steadily, giving about 80 energetic pick strokes per minute, being gradually worked forward by a hand-wheel (by the attendant sitting on the machine), on a common 2½ inch tramway, without anything but its own weight to keep it steady. The coal seam being a very dirty one, the pick occasionally struck pyrites, when the speed was somewhat retarded; 10 yards along the face was measured for the purpose of timing. That distance was kirved to a depth of about 24 in. in 17 minutes; the machine was then run back to take a second cut of about 18 in. more depth, making the depth of cut altogether 3 ft. 6 in. This second cut was completed in 18 minutes, although much pyrites was met with, which considerably blunted the pick.

Thus, altogether the 10 yards of kirving, to a depth of 42 in., was done in 35 minutes, independent of the time lost in running the machine back.

Kirving to this depth the 50 yards bank, as well as slewing

the road, is considered a day's work for two men, and is done at this colliery, I believe, for 3d. a yard.

The same patentees also make a machine with straight cut, working on the same principle as a slotting-machine, but having three cutters set in advance of each other, about 12 ins. apart, on the same bar; thus, when the piston to which this cutting-bar is directly attached makes a stroke of 12 in., the three cutters together make a cut of 36 in. depth. There is much more direct strain upon this machine, necessitating a stronger and more permanent road arrangement, and the machine is fed forward and travels on a system of cast-iron racks laid down upon cast-iron transverse sleepers at every joint; these transverse pieces carrying on their extreme ends furthest from the face cast-iron adjustable props against the roof, the whole forming a very strong and compact road arrangement, said to be easily slewed forward.

The machine is further steadied when working by a very ingenious system of roof-pressure, consisting of a ram at the top of the machine, which is pressed upwards by the air pressure, thus completely steadying the machine between the roof and the floor.

I also timed this machine, and it cut 5 yards to a depth of 3 ft. once over in 17 minutes.

Thus it appears the two machines do about the same amount of work in the same time, as although the pick-machine cut 6 in. deeper, still a certain amount of time is lost in returning for the second cut, which is avoided in the straight cut. On the other hand, the road arrangement in the straight-cut machine, is much more expensive and cumbersome to move than in the pick-machine, the latter only working on an ordinary tramroad, without anything being necessary to steady it.

Both machines worked remarkably well, and the air was cool and fresh. When it is remembered that a collier with uncommonly burdensome labour will only kirve about 7 to 8 yards a day in the same bed of coal, and when we consider the great saving in making less small, and the means of perfect ventilation, which this system of working of coal-cutting machinery affords, by constantly delivering a certain quantity of pure cool air at the very face of the working, with power at an emergency to send in a larger volume, and when further here is a system actually at work, passed the stage of experiments, and now a practical success, then I think I cannot be far wrong in my impression, from the inspection, that this machinery cannot fail gradually to supersede the present system of hand pick-labour, and ought to be hailed both by colliery owners and colliers as a boon.

Middlesbro'-on-Tees.

J. G.

TABLES REFERRED TO IN MR. FAIRBAIN'S PAPER ON THE PROPERTIES OF STEEL.*

(See Page 233 of our last number.)

TABLE I.—SUMMARY OF RESULTS OF THE EXPERIMENTS ON TRANSVERSE STRAIN.

No. of detailed Experiment.	MANUFACTURER.	Mark on Bar.	Mean value, D, of the Deflections for unit of pressure and section. By eq. (6).	Mean value of the modulus of Elasticity, E. By eq. (7).	Modulus of Elasticity, E, corresponding to 112 lb. pressure. By eq. (2).	Work of Deflection, V, up to the limit of Elasticity. By eq. (8).	Work of Deflection, U, for unit of section. By eq. (9).	Value C, the unit of working strength. By eq. (12).	REMARKS.
1	Messrs. Brown and Co...	B1	.0012048	32,672,000	33,047,000	52,280	55,563	tons.	Sunk with 1150 lb.
2		B2	.0013377	29,415,000	29,465,000	59,280	63,003	6,326	"
3		B3	.0012891	30,550,000	32,171,000	72,838	72,690	6,958	"
4		B4	.0012581	29,463,000	29,370,000	52,720	54,893	6,134	Sunk with 1150 lb.
5		B5	.0012673	29,248,000	31,510,000	53,480	55,685	6,134	"
6		B6	.0013024	30,224,000	32,361,000	42,068	42,749	5,297	Sunk with 950 lb.
7		B7	.0012643	31,135,000	33,523,000	43,900	45,897	5,527	"
8		B8	.0012863	29,335,000	30,686,000	43,358	44,598	5,394	"
9		B9	.001258	31,292,000	31,833,000	38,416	39,416	5,170	"
10	Messrs. Cammell and Co.	1	.0013081	30,088,000	29,996,000	95,000	85,515	7,504	"
11		2	.001637	22,965,000	24,283,000	102,443	84,048	6,904	"
12		3	.0012612	31,212,000	31,474,000	77,864	78,825	7,418	"
13		4	.0013254	29,700,000	30,126,000	44,240	40,902	5,132	"
14		5	.0012803	30,742,000	33,205,000	33,750	32,439	4,588	Sunk with 950 lb.
15		6	.0012995	30,291,000	31,056,000	37,057	37,657	4,988	"
16	Messrs. Naylor and Vickers	A	.001273	30,823,000	30,940,000	44,741	44,741	5,472	Sunk with 1150 lb.
17		S	.0013124	29,994,000	27,847,000	40,025	40,194	5,505	"
18		S	.0013386	29,407,000	29,385,000	99,463	94,485	7,856	"
19		S26	.0012789	30,788,000	29,752,000	82,412	80,798	7,358	"
20	Messrs. Osborn and Co...	O1	.0013886	28,333,000	26,689,000	50,668	48,813	5,432	"
21		O2	.001278	30,802,000	30,528,000	64,195	62,684	6,400	Sunk with 1300 lb.
22		O3	.0017814	22,098,000	22,072,000	54,287	47,845	4,691	" 1250 lb.
23		O4	.0013409	29,368,000	29,718,000	56,433	56,435	6,037	"
24		O5	.0013112	26,398,000	29,610,000	50,079	53,194	5,559	Sunk with 1300 lb.
25		O6	.0016881	23,319,000	23,948,000	31,792	29,393	4,329	" 1200 lb.
26		O7	.001348	29,188,000	28,013,000	75,776	72,826	6,860	"
27		O8	.0013007	30,335,000	29,585,000	50,000	49,406	5,671	Sunk with 1300 lb.
28	Messrs. Bessemer and Co.	BS2	.0021814	29,652,000	29,104,000	70,762	72,199	6,882	"
29		BS2	.0012946	30,478,000	28,379,000	42,087	41,261	5,317	Sunk with 1100 lb.
30		BS3	.0015293	29,310,000	28,536,000	32,364	35,008	4,778	" 850 lb.
31	Messrs. Sanderson Brothers	S1	.0012822	30,700,000	31,432,000	52,116	47,462	5,539	"
32		S2	.0013412	29,351,000	28,074,000	39,433	37,022	4,808	Sunk with 1350 lb.
33		S3	.0012963	30,368,000	29,858,000	71,390	68,082	6,780	"
34		S4	.0013516	29,922,000	29,184,000	51,675	47,230	5,572	"
35		S5	.0013333	29,524,000	28,179,000	40,078	37,269	4,907	Sunk with 1200 lb.
36	Messrs. T. Turton and Sons	A	.0013033	30,204,000	30,895,000	46,400	45,369	5,592	Sunk with 1150 lb.
37		B	.0012953	30,890,000	31,297,000	71,087	66,748	6,625	"
38		C	.0012598	31,247,000	31,859,000	65,443	65,705	6,718	"
39		D	.001287	30,887,000	32,462,000	59,253	60,949	6,337	Sunk with 1250 lb.
40		E	.001303	30,211,000	30,764,000	67,763	65,131	6,576	"
41		F	.001302	30,218,000	32,480,000	46,240	44,444	5,440	"
42		G	.001295	30,398,000	31,325,000	51,600	52,120	5,861	Sunk with 1150 lb.
43		H	.001382	28,84,000	27,542,000	50,800	49,602	5,570	" 1250 lb.
44		I	.001368	31,198,000	27,646,000	52,704	54,877	5,788	" 1050 lb.
45		U	.001325	29,710,000	31,232,000	33,277	31,869	4,561	" 1250 lb.
46	Messrs. The Titanic Iron and Steel Company—Mushets steel	AX	.001265	31,119,000	32,120,000	115,522	114,600	8,682	"
47		BX	.001177	33,446,000	34,935,000	51,846	52,892	6,621	"
48		CX	.001237	31,823,000	34,879,000	49,960	49,76	5,739	"
49		DX	.001261	31,218,000	30,418,900	39,345	36,915	4,699	"
50	The Hematite Iron and Steel Company	H1	.001308	30,096,000	33,830,000	77,944	77,917	6,860	"
51		H2	.001280	30,754,000	34,443,000	14,242	14,383	3,108	"
52		H3	.001319	29,717,000	32,717,000	20,155	19,767	3,840	"

* Read before the British Association at Dundee.

TABLE II.—SUMMARY OF RESULTS OF THE EXPERIMENTS ON TENSILE STRAIN.

No. of detailed Experiment.	MANUFACTURER.	Mark on Bar.	Specific Gravity of Specimen.	Weight laid on in lb. producing rupture.		Breaking Strain per square inch of section.	Corresponding Elongation per unit of length, or value $V = \frac{L}{L_0}$.	Value of U, or work producing rupture, by eq. (13).	REMARKS.
				lb.	tons.				
1	Messrs. Brown and Co....	B1	...	31,849	68,404	30.53	.0056	191	Broke in neck.
2		B2	...	39,784	91,520	40.85	.0150	686	"
3		B3	...	30,371	106,714	47.64	.0143	763	"
4		B4	...	49,564	116,183	51.86	.0337	1937	"
5		B5	...	31,916	110,055	49.13	.0375	2063	"
6		B6	...	39,764	91,972	41.05	.0837	4522	"
7		B7	...	39,799	92,555	41.31	.0406	1878	"
8		B8	...	22,211	76,474	34.27	.0968	3715	Broke 1 in. from the neck.
9		B9	...	17,171	59,538	26.57	.0762	2268	Broke in centre.
10	Messrs. Cammell and Co.	1	...	31,916	110,055	49.13	.0177	974	Broke 2½ in. from the neck.
11		2	...	31,871	109,072	48.69	.0206	1123	Broke in neck.
12		3	...	35,066	120,398	53.75	.0281	1691	"
13		4	...	41,344	96,665	43.15	.0250	1208	"
14		5	...	38,224	89,121	39.78	.1437	6403	Broke near centre.
15		6	...	23,891	81,483	36.37	.1200	4888	"
16	Messrs. Naylor and Vickers ...	A	...	25,571	88,665	39.58	.0625	2770	Broke in centre.
17		T	...	39,784	91,520	40.85	.0475	2173	Broke 2½ in. from the neck.
18		S	...	57,374	134,145	59.87	.0100	670	Broke in the neck.
19		S26	...	35,066	118,066	52.70	.0287	1694	"
20	Messrs. Osborn and Co.	O1	...	43,129	98,942	44.17	.0156	771	Broke in neck.
21		O2	...	51,899	123,686	55.21	.0318	1966	"
22		O3	...	49,549	115,849	51.71	.0298	1726	"
23		O4	...	41,344	98,790	44.10	.0181	894	"
24		O5	...	44,464	103,116	46.03	.0431	2222	"
25		O6	...	38,224	87,931	39.25	.0243	1068	"
26		O7	...	36,664	85,724	38.26	.0037	158	"
27		O8	...	47,764	111,676	49.85	.1062	5930	Broke in centre.
28	Messrs. Bessemer and Co.	BS1	...	42,904	103,085	46.02	.0187	963	Broke in two places.
29		BS2	...	38,224	88,175	39.36	.1093	4818	Broke near centre.
30		BS3	...	33,439	78,606	35.09	.0981	3855	Broke in centre.
31	Messrs. Sanderson Brothers ...	S1	...	31,849	83,484	37.26	.0187	780	Broke in neck.
32		S2	...	46,054	107,940	48.18	.0318	1716	"
33		S3	...	42,904	107,182	47.84	.0275	1473	"
34		S4	...	32,689	75,199	33.57	.0437	515	"
35		S5	...	44,464	103,960	46.41	...	1782	"
36	Messrs. T. Turton and Sons ...	A	...	41,344	100,155	44.71	.0312	1562	Broke in neck.
37		B	...	38,164	87,552	39.08	.0106	464	"
38		C	...	41,344	95,372	42.57	.0181	863	"
39		D	...	31,849	80,273	35.02	.0018	72	"
40		E	...	44,614	102,915	45.94	.0181	929	"
41		F	...	44,464	102,567	45.79	.0206	1056	"
42		G	...	46,054	106,237	47.42	.0243	1290	"
43		H	...	38,224	87,471	39.04	.0131	572	"
44		I	...	41,344	97,994	43.74	.0193	945	"
45		U	...	31,849	73,266	32.70	.0087	318	"

TABLE III.—SUMMARY OF RESULTS OF THE EXPERIMENTS ON COMPRESSION.

No. of detailed Experiment.	MANUFACTURER.	Mark on Bar.	Greatest weight laid on per square inch.		Corresponding compression per unit of length.	Value of U, or work expended in crushing the bar, by eq. (13).	REMARKS.
			lb.	tons.			
1	Messrs. John Brown and Company ...	B1	225,568	100.700	.253	28,533	One very slight crack appeared.
2		B2	225,568	100.700	.263	29,592	No cracks.
3		B3	225,568	100.700	.183	20,591	One very slight crack of outside skin.
4		B4	225,568	100.700	.293	32,968	No cracks.
5		B5	225,568	100.700	.243	27,342	"
6		B6	225,568	100.700	.403	46,345	"
7		B7	225,568	100.700	.443	49,846	Three large cracks, with several smaller.
8		B8	225,568	100.700	.493	55,472	Much cracked.
9		B9	225,568	100.700	.553	62,223	"
10	Messrs. Charles Cammell and Company ...	1	225,568	100.700	.233	26,217	No cracks.
11		2	225,568	100.700	.263	29,592	"
12		3	225,568	100.700	.313	35,218	"
13		4	225,568	100.700	.303	34,171	Very slight cracks.
14		5	225,568	100.700	.433	48,721	No cracks.
15		6	225,568	100.700	.493	55,472	"
16	Messrs. Naylor, Vickers, and Company ...	A	225,568	100.700	.423	47,596	No cracks.
17		T	225,568	100.700	.388	43,758	"
18		S	225,568	100.700	.153	17,255	"
19		S26	225,568	100.700	.183	20,591	"
20	Messrs. Osborn and Co., Sheffield ...	O1	225,568	100.700	.203	22,841	No cracks.
21		O2	225,568	100.700	.243	27,342	"
22		O3	225,568	100.700	.253	28,467	"
23		O4	225,568	100.700	.263	29,592	"
24		O5	225,568	100.700	.323	36,344	"
25		O6	225,568	100.700	.323	36,344	"
26		O7	225,568	100.700	.193	21,716	"
27		O8	225,568	100.700	.333	37,469	"
28	Messrs. Bessemer and Company ...	BS1	225,568	100.700	.223	25,092	No cracks.
29		BS2	225,568	100.700	.443	49,846	"
30		BS3	225,568	100.700	.473	53,222	"
31	Messrs. Sanderson Bros.	S1	225,568	100.700	.398	44,783	Two large cracks.
32		S2	225,568	100.700	.303	34,093	Very slight crack.
33		S3	225,568	100.700	.283	31,843	No cracks.
34		S4	225,568	100.700	.323	36,344	Several slight cracks.
35		S5	225,568	100.700	.333	37,469	Much cracked.
36	Messrs. Thomas Turton and Sons ...	A	225,568	100.700	.283	31,843	No crack.
37		B	225,568	100.700	.193	21,216	"
38		C	225,568	100.700	.343	27,342	"
39		D	225,568	100.700	.263	29,592	"
40		E	225,568	100.700	.233	26,217	"
41		F	225,568	100.700	.253	28,467	"
42		G	225,568	100.700	.233	32,968	"
43		H	225,568	100.700	.273	30,718	"
44		I	225,568	100.700	.273	30,718	Very slightly cracked.
45		U	225,568	100.700	.293	32,968	No cracks.

MR. BRASSEY AND LORD REDESDALE.

TO THE EDITOR OF ENGINEERING.

SIR,—It must be consoling to you, as well as to the public in general, to know that the nineteenth century is not to be allowed to pass over without one discovery at least worthy of these times.

I allude, of course, to the wonderful discovery which Lord Redesdale has made and written so much to the *Times* about. This discovery, for the benefit of those who have not had the advantage of seeing the noble lord's own account of it, may be briefly, but nevertheless accurately described as the discovery of a genuine mure's nest, worth no less than 40,000*l.* which, but for his lordship's wonderful sagacity in finding it out, would, doubtless, by this time have been quietly appropriated by various gentlemen, amongst whom are Mr. Baxter, Mr. Bidder, Mr. Brassey, Mr. Sinclair, Mr. Maynard, the Great Eastern Railway directors in general, and a few other equally obscure and unknown individuals, or, as the noble lord is pleased to call them, "swindlers and jobbers."

Having taken the trouble to make myself fully acquainted with the facts of this case, you will, no doubt, hear with regret that all my sympathies are with "the swindlers and jobbers," so perverted does my sense of the right and wrong in it seem to have become; and the more I study this wonderful discovery of Lord Redesdale, the less do his claims for public admiration and gratitude appear to me to become.

The matter in question has been set forth in so much detail that it has not been on all points properly understood, even by some of your contemporaries who have taken upon themselves to make it so, but the principles involved are so simple that I am induced to present them to you in a plain straightforward fashion, that can be understood by those who have neither time nor inclination to wade through needless details, and in doing so I shall endeavour to adhere to nothing but facts which have, I think, been proved in the recent correspondence to the satisfaction of every reasonable person.

In the session of 1861, the now celebrated Bishopstortford, Dunmow, and Braintree was promoted by an independent company before Parliament, and an Act obtained for its construction. The line being situated in the Great Eastern district, and wholly isolated from any other railway system other than the Great Eastern, the usual clauses in such cases were introduced to give these two companies general powers to make working and traffic arrangements with each other, and to enable the Great Eastern (if they thought fit) to subscribe 40,000*l.* towards the cost of the Dunmow line.

In the next session (1862) the Great Eastern obtained an Act for power to "absorb" two small railways (which have since been made), and, further, to abandon a third line, on the ground that the Dunmow line would render this other line unnecessary.

In granting this Act of 1862, Parliament imposed a somewhat unusual condition on the Great Eastern Company, namely, that if the Dunmow Railway was not finished by a certain time, the Great Eastern should be prohibited from paying their own ordinary dividends; in other words, the Great Eastern were to be heavily fined (for this fine was then considered as a very heavy one) if their neighbour and *protégé*, the Dunmow Company, did not get their line made by a certain time. This being the case, the Great Eastern, as it appears to me every reasonable individual would have done under similar circumstances, began to bestir themselves and take an initiative (in which Mr. Bidder takes an active part) in getting this line made. Parliament had treated them as responsible for this, and it need not therefore be surprising (except, perhaps, to Lord Redesdale) to find that they set about having the line made as if it was practically one of their own branches.

On this point Lord Redesdale insists that the Great Eastern had no right whatever to take action in having the Dunmow line made; and if this be so, that the Great Eastern had no right to take measures for getting a thing done that they were bound under a penalty by Act of Parliament to see done by a certain time; then they merely made a not very unnatural mistake in arranging for the construction of the line with Mr. Brassey.

Perhaps, however, Lord Redesdale's opinion on this point might be modified if he would put himself in the position of the Great Eastern Company after the passing of the Act of 1862. The noble lord is, let us suppose, to be deprived of his income by Act of Parliament, if a neighbour (let us call him Mr. Brassey) does not get a house he is building for himself finished by a certain time. Under precisely similar circumstances, Lord Redesdale declares that he would have no right whatever to take measures to ensure Mr. B.'s house being finished within the prescribed time; he would have waited patiently till next session, and got an Act to enable him to do it legally, he says. But as the Great Eastern Railway Company had not in these days the advantage of knowing what Lord Redesdale has so kindly found out for them since, namely, that the condition imposed on them by Parliament in 1862 could not be legally carried out, they took the initiative in making the Dunmow line, apparently considering, under the circumstances imposed on them by Parliament, that they had no occasion to think of any other course.

Here, then, is the foundation of Lord Redesdale's discovery, which I will now go on further to describe.

The Great Eastern, under the impressions produced by this clause, proceeded to arrange with Mr. Brassey for the construction of the line at a schedule of prices approved of by their engineer, Mr. Sinclair; and, to enable them to carry out the bargain they made with Mr. Brassey, they got power, in 1863, to guarantee the interest of the Dunmow shares and debentures. These facts harmonise with the theory that the Great Eastern now considered themselves as being prospectively, if not virtually, the Dunmow Company.

But now comes the Act of 1865, which Lord Redesdale calls the only legal and binding agreement between the companies. This was an Act to enable the Great Eastern to purchase the Dunmow line, and thus officially carry out what had already become practically a fact, that the Dunmow line was theirs as soon as they paid for it, which this Act authorised them to do.

Had it not been for what Lord Redesdale has been assured over and over again was a mere unintentional blunder in one of the clauses of this last-named Act, the whole matter would

never have been heard of, and Lord Redesdale's fame as a discoverer of "jobs" might not have reached the climax it now has. However, in the clause giving the Great Eastern power to purchase the Dunmow line, the words occur, "*but the total amount to be paid shall not exceed the sum of 80,000L.*" This sum of 80,000L makes up, together with the Great Eastern contribution of 40,000L, which had already been spent on the land and the 40,000L of debentures Mr. Brassey had received on account, the total capital authorised to be raised by the original Act, viz., 160,000L shares and debentures. Now had the cost of the line been within the Parliamentary capital, there would have been nothing to complain of in this clause; but unfortunately the framers of it took this for granted, without consulting Mr. Brassey or the engineer, and inserted the 80,000L limitation in ignorance of the fact that the cost of the line (which was to be paid for in paper *after* its completion) would be considerably in excess of the Parliamentary capital; nor is this by any means an extraordinary or unusual circumstance, when the mode of payment (a very general one now) is borne in mind.

Mr. Brassey in 1862 had taken the contract at an agreed schedule of prices, and it is now found that the cost of the finished works by this schedule is 160,000L; but the land, &c., having taken about 40,000L, there only remains 120,000L of the original capital to pay for these works. Had this been known or foreseen by the framers of the Act of 1865, they could never have fallen into the mistake of limiting the purchase money to a sum insufficient to pay the cost of making the line. Mr. Brassey had got 40,000L in debentures, and he therefore wanted a balance of 120,000L (instead of 80,000L, as in the Act of 1865) to pay his account.

When these facts were clearly ascertained, the directors of the Great Eastern determined to take the only course which, as honourable men of business, was open to them. By an unintentional blunder in their Act of 1865, they had put themselves and Mr. Brassey, without the latter gentleman's knowledge, in a false position, and their duty was clear in taking measures to relieve themselves and him from it as soon as possible, and this they did by applying for power in their last session's finance bill to pay Mr. Brassey the 40,000L additional he was justly entitled to under his contract with them of 1862.

Here, then, is the great swindle and job! The Great Eastern solicitors, directors, engineer, and who knows else beside, conspiring to give Mr. Brassey 40,000L, which, no doubt (as Lord Redesdale apparently thinks), is to be comfortably divided amongst themselves on the first quiet opportunity!

Perhaps his lordship's mistake might have been pardoned if he would listen with moderation to the numerous explanations that have been made on this subject to him by those who are correctly informed about it; but they only seem to make the matter worse in his eyes; and, indeed, the only way in which the position he maintains in the matter can at all be understood is, by taking his assumption that the line has not in reality cost more than the original authorised capital (a fact that may very easily be ascertained), and that the 40,000L additional is a mere "grab" at the Great Eastern cash-box by a set of "swindlers."

When the position and character of the various gentlemen who are thus designated is considered, it may appear rather surprising that some weight should not be attached to their explanations by the noble lord. But, so far from this being the case, some of them have been held up to the public in a most unenviable light. Thus, Mr. Bidder was only "Mr. Brassey's nominee" on the Great Eastern board, and his motive in participating in the job becomes at once plain to Lord Redesdale. Mr. Sinclair was "required to resign after the late investigation," according to him, and therefore there can be no doubt as to his share in the transaction; and about Mr. Brassey there can be no mistake at all, he seems to think. These gentlemen, however, naturally show some slight objections to accept these wholesale charges, required as they may be to support Lord Redesdale's theory. Mr. Bidder appears resolved to find some tangible means of rebutting them, and Mr. Sinclair, unhappily for Lord Redesdale, is still the well-known and much-respected engineer of the Great Eastern Railway, and although he resigned the less important part of his duties some time since, in order that he might give his undivided attention to the more important ones, this, as every one knows but Lord Redesdale, had no more to do with the late investigation than that nobleman's letters in this case have to do with moderation and fairness. The fact of such a charge having been based on such miserable grounds will, I think, be found to be a fair specimen of the other charges he has made in this case.

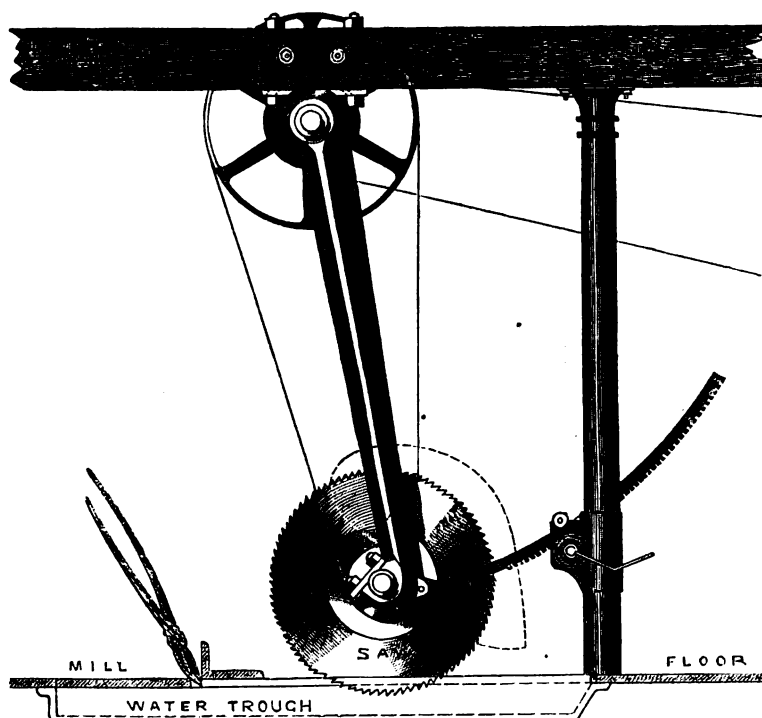
In conclusion, the circumstances are briefly these: the Great Eastern, rightly or wrongly, made a contract with Mr. Brassey to do certain work, under which it is found he is entitled to 160,000L; but the company have subsequently unintentionally, and without his knowledge, limited themselves to paying him only 80,000L, in addition to 40,000L which he has received already. Lord Redesdale says, "Never mind anything else but this limitation—all the rest of your bargain was illegal, so 'don't give Mr. Brassey a shilling more than the 80,000L.'" The company's position is this, that although they perhaps could, through a mere unintentional blunder, refuse to pay a just debt of 40,000L, for which they are by every principle of morality and fairness liable, they will not take such an advantage of this blunder, but pay this just debt; and further, this is the conduct and principles which are denounced so intemperately as a "swindle" and a "job," and I know not what else besides, by the noble chairman of committees of the House of Peers.

"Now let us sing, long live the Queen,
And Redesdale, long live he;
And when the next mare's nest he finds,
May we be there to see."

Your obedient Servant,
Westminster, September 16, 1867. M.

WATERFORD.—This port, which has been steadily progressing of late, owing to the enterprise of Messrs. Malcolmson, is about to make another step in advance by the establishment of a dry dock near the city. Mr. Stephen, the engineer of the Local Harbour Commissioners, has examined a suitable site, and has furnished an estimate of the probable cost amounting to 42,570L. The works are expected to be shortly commenced.

SAWING IRON.



TO THE EDITOR OF ENGINEERING.

SIR,—Reading your account of the Downais rolling mills, I was struck with the clearness with which you describe the process of sawing the heavy bars of girder or other iron.

It recalls to my mind that it has often appeared to me an improvement might be effected in the arrangement of the saw or saws in many bar and angle iron mills that would economise labour, and I enclose you a rough sketch that will exemplify my idea at a glance.

The long traversing table of a saw of the present form is a cumbersome, clumsy thing. To lift a heavy bar on to it entails a considerable amount of labour, and the certainty of more or less twisting the iron in the process, which, with some sections, is a serious matter.

Mahomet found it simpler to go to the mountain than to bring the mountain to him; and why not, instead of taking these heavy bars to the saw, bring the saw to the bars?

By suspending the saw from above on a frame working on the same centre as the driving sheave, a traverse of any length, through a simple slot in the mill floor, may be obtained, traversing tables and labour avoided, much space economised, as the saw may be kept as close as desired to the rolls. The dragger-out simply pulls the bar straight forward, puts his tongs into one of the perforations in the floor plates at the back of the iron to be cut, and forward comes the saw; the iron is again dragged on, still in a straight line, and the other end served the same. No twisting or lifting the iron; all a straightforward pull, done in half the time usually taken, and at much less cost.

As a practical man I can't see why it should not answer admirably for all descriptions of bar and section iron mills at any rate, and even be adapted to cutting the edges of armour and other plates too thick for the shears. I think it ought to do.

Yours truly,

JOHN DIXON.

5, Abchurch-yard, London, Sept. 2, 1867.

GOVERNMENT COMPETITION IN INDIA.

TO THE EDITOR OF ENGINEERING.

SIR,—Permit me to draw your attention to the following extracts relative to the manufacture of agricultural implements by the Government of Madras. They are taken from a letter written by the Superintendent of the School of Arts, Madras, and addressed to the superintending engineer, Punjab, and of which an abridgment appeared a short time since in the *Madras Times*:

"Considerable success has attended the employment of European agricultural implements that have been lately received from England. The implements that have been most useful are Howard's iron ploughs. We have made about twenty-eight of them, and more have been made at the Gun Carriage Manufactory, Mint, and D. P. Workshops.

"Several gentlemen got chaff-cutting machines made at the Mint, and find them of use in feeding horses and cattle."

I am led to add that the manufacture of agricultural machinery is regularly carried on at the workshops of the Civil Engineering College at Rowkee, North-West Provinces.

It appears to me that the only inference to be drawn from these facts is that the Government are successfully competing with the home manufacturers, and I think that it becomes such of the latter who, like myself, are interested in the export trade, to make themselves acquainted with the circumstances which have brought about such a state of affairs. Desiring such information myself, I am induced to ask the insertion of these remarks in your esteemed journal.

I am, Sir, your obedient Servant,

M.

HULL.—The Amalgamated Society of Engineers at Hull has resolved not to accede to a proposed reduction of wages.

PERFORMANCE OF STEAMSHIPS.

TO THE EDITOR OF ENGINEERING.

SIR,—I observe that, in your paper of the 13th, you have reprinted what you consider to be the Report of the Committee of the British Association on the above-mentioned subject. It is right that I should inform you that the proofs of that Report are still under consideration by the members of the committee, and have not yet received their final revision and sanction, and that it is possible that alterations may still be required. No proofs of the Report have yet been furnished to any journal with the knowledge and sanction of the committee.

I am, Sir, your most obedient Servant,

W. J. MACQUORN RANKINE.

59, St. Vincent-street, Glasgow, September 17, 1867.

THE SOCIETY OF ENGINEERS AND THE INSTITUTION OF CIVIL ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—Having read the articles and letters in your valuable paper in reference to the above two societies, and having heard, upon the occasion of the Society of Engineers' recent visit to Mr. Penn's works, an explanation of the position of affairs resulting from the peculiar course adopted by the Institution of Civil Engineers, I, as one of the members of the Society of Engineers, think it would be advisable for our council and members, at the first meeting in October, to consider the steps taken by the president of the Institution, in order that nothing in the shape of disagreement may supervene.

One cannot but mark with surprise and regret that an influential association such as the Institution of Civil Engineers undoubtedly is, and one, moreover, which has been so highly looked up to by the profession, should have called forth the remarks made by the president of the French Society of Civil Engineers on the occasion referred to in your impression of the 6th instant. Almost at the same moment these two representative bodies, one in Paris and one in London, were engaged in considering a similar subject, and the different conclusions arrived at are really of a very curious character. One society extends the most cordial help and recognition under precisely similar circumstances, wherein the other society not only refuses help, but commences to make war. This dissimilarity of conduct has provoked on the part of the President of the Société des Ingénieurs Civils the belief that the Institution of Civil Engineers has laid itself open to grave charges of selfishness and monopoly. "No one is to be an engineer but ourselves." This is to keep up "trade freedom" and "trades' unions," says M. Eugene Flachet. Now, it seems very desirable that such an unenviable reputation as this should not attach to one of our foremost institutions simply on account of some probable misunderstanding. Unless the council of the Institution deliberately set before themselves, as a principle, the persecution of the Society of Engineers, I should be disinclined to consider that the Institution is anxious to acquire such a character as that which has been attributed to it. I would ask, is there no way by which the objects of the Society of Engineers could be obtained with the direct concurrence of the Institution, now that it has been discovered how readily its enmity may be aroused?

If the Institution of Civil Engineers is determined to pursue that policy which has attracted the attention of distinguished members of the profession abroad, and called apparently for no graceful comment, would it not be advisable to consider some other means of accomplishing what is required in the interests and protection of the Society by incorporation by Act of Parliament (1862), thereby saving to the Society the expenses of a Parliamentary contest, or such expense as would be entailed in the obtaining of a Royal Charter?

The future position of the Society of Engineers will not depend on its particular act of incorporation, but on the individual members who compose its body.

I am, Sir, your obedient Servant,

A MEMBER OF THE SOCIETY OF ENGINEERS.

STEAM-SHIP PERFORMANCES.

(Continued from page 218.)

TABLE IV.—MEN-OF-WAR (GROUP 2, continued).

Groups of a Speed ...	2. Between 7 and 9 knots.											
Subgroups of Displacement ...	E. Between 1000 and 2000 tons.											
Name of Vessel ...	Falcon.	Supply.	Harrier.	Archer.	Eurotas.	Malacca.	Cossack.	Phoenix.	Wyoming, U.S.	Niger. Half-boiler power	Conflict.	Forth.
Length in water-line, in feet ...	160	179.5	160	186.33	166.16	192	195	174.5	209.75	194.33	192.54	159
Breadth (extreme), in feet ...	31.83	27.12	31.83	33.83	40.83	34.33	38.5	31.83	38	34.67	34.33	42.16
Tonnage, builder's measurement ...	748	638	747	970	1201	1034	1322	809	997	1072	1038	1228
Mean draught of water, in feet ...	14	14.25	14.75	14.75	15.29	14.16	14.04	15.62	13.29	15.79	15.08	17.62
Area of immersed midship section, square feet ...	330	324	378	356	387	377	383	405	391	437	421	493
Displacement, in tons of 35 cubic feet ...	1006	1070	1097	1263	1293	1363	1365	1460	1475	1496	1530	1704
ENGINES.												
Description ...	Hor.	In. Sing. Tr.	Hor.	H. geared	H. Tr. H. P.	H. Tr. H. P.	Hor.	V. o. geared.	Hor.	Hor.	Hor.	H. Tr. H. P.
Number of cylinders ...	2	2	2	2	2	2	2	2	2	4	4	2
Diameter of cylinders, in inches ...	32	=34.5	34	46.01	=30.25	=23	51	62.25	50	47.625	46.25	=30.25
Length of stroke, in feet ...	2	2.25	1.75	3	2.5	2.5	2.25	4.5	2.5	1.83	2	2.5
Number of revolutions per minute ...	81.5	45	93.83	42	93.33	87	66.33	22	52.5	55	72	110
Weight per sq. in. on safety-valve, in lb. ...	20	14	20	10	60	60	12	10	17	12	10	60
Nominal horse power ...	100	80	100	200	200	200	250	260	...	400	400	200
Indicated horse power ...	312.2	265.2	323.5	447.1	561.8	675	573.4	524.1	...	481.8	790	814
PROPELLER.												
Diameter, in feet ...	10.02	10	10	9	12	13.5	12.08	11.87	13.08	12.5	13.52	12
Pitch, in feet ...	11.77	12	11.12	7.25	10	11.12	16.57	9.33	19	17.25	16.37	10
Length in line of shaft ...	1.98	1.67	1.92	1.33	1.67	1.85	2.75	1.60	2.5	2.48	2.78	1.67
Immersion at bottom, in feet ...	7	8.57	8.33	7.08	10.57	6.25	6.57	6.75	...	8.25	7.83	11.57
Number of revolutions per minute ...	81.5	45	93.83	126	93.33	87	66.33	88	52.5	55	72	110
Speed of ship, in knots per hour ...	7.87	8	7.655	7.8	7.579	8.708	8.655	7.674	7.1	7.6	8.85	8.6
Speed of propeller ...	9.465	10.653	10.297	9.011	9.206	9.547	10.851	8.536	...	9.859	11.630	10.851
Slip, in knots per hour ...	1.595	2.653	2.642	1.211	1.627	0.889	2.196	0.862	...	1.759	2.780	2.251
Slip per cent. ...	16.85	24.91	25.66	13.44	17.68	8.79	20.24	10.10	...	18.80	23.90	20.74
Speed ³ × $\frac{1}{D}$ ÷ indicated horse power ...	515.2	625.5	493.6	401.2	299.9	367.8	438.1	349.2	...	444.2	369.4	385.2
Speed ³ × $D^{\frac{2}{3}}$ ÷ indicated horse power ...	156.7	202	147.5	124	92	120.3	139.1	...	...	133	116.5	...
Wind ...	No. 3	...	No. 3	...	...	No. 2	...	...	...	...	No. 3 to No. 4	Fresh breeze.
Sea ...	...	...	...	...	...	...	...	...	...	...	Light swell.	Little swell.
Remarks ...	...	...	...	...	Vessel not in trim.	...	...	...	...	...	...	...
Reference to Reports ...	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862

Groups of a Speed...	2. Between 7 and 9 knots.											
Subgroups of Displacement ...	F. Between 2000 and 4000 tons.											
Name of Vessel ...	Russell.	Pem- broke.	Arrogant.	Edin- burgh.	Majestic.	Hogue.	Hannibal.	Brun- swick.	Centurion.	Cressy.	Sans- pareil.	Nile.
Length in water-line, in feet ...	176.5	176	200	176.5	190	184	217.5	190	190	198.42	200	205.5
Breadth (extreme), in feet ...	48.33	48.5	45.73	48.61	56.75	48.37	48.13	55.75	57.08	55	52.25	54.29
Tonnage, builder's measurement ...	1751	1758	1872	1772	2590	1846	3136	2484	2590	2540	2339	2622
Mean draught of water, in feet ...	12.85	19.5	19.41	22.12	21.75	22.49	20.55	24.24	24.37	24.41	24.14	24.96
Area of immersed midship section, square feet ...	585	660	604	785	749	805	777	882	895	855	994	1013
Displacement, in tons of 35 cubic feet ...	2106	2465	2565	3005	3028	3081	3300	3632	3680	3707	3800	4480
ENGINES.												
Description ...	H. Tr. H.P.	H. H. P.	H. Trunk	Hor.	Hor.	Hor.	H. geared.	Hor.	Hor.	Hor.	Hor.	Hor.
Number of cylinders ...	2	2	2	4	2	4	2	2	2	2	2	4
Diameter of cylinders, in inches ...	=30.25	30	=55	55	64	51.5	71.25	64	64	64	64	62.25
Length of stroke, in feet ...	2.5	2.5	3	2.5	3	3	4	3	3	3	3	3.5
Number of revolutions, per minute ...	103	82	64.833	52	49.4	56	27.5	53.5	54	48.2	58	30
Weight per square inch on safety-valve, in lb. ...	60	65	12	6	20	10	12	20	20	20	15	16
Nominal horse-power ...	200	200	360	450	400	450	450	400	400	400	400	500
Indicated horse-power ...	701.3	572	894.8	963.6	1199.1	797.3	1071.2	1438	1255	1076.3	1471	1247.3
PROPELLER.												
Diameter, in feet ...	12	12	15.5	16	17	16.06	17	17	17	17	16	17
Pitch, in feet ...	9.5	12	15.46	18.75	21	18.75	12.5	20.57	21	21	23	16
Length in line of shaft ...	1.57	2	2.42	3.08	3.5	3.33	2.08	3	3	3.08	3	2.67
Immersion at bottom, in feet ...	10.46	12.68	10.16	11.71	11.57	12.5	8.83	14.16	13.57	12.92	14.20	13.92
Number of revolutions, per minute ...	103	82	64.833	52	49.4	56	64.87	53.5	54	48.2	58	60
Speed of ship, in knots per hour ...	7.5	7.602	8.935	8.498	8.783	8.328	8.6	7.742	8.5	7.206	9.3	8.2
Speed of propeller ...	9.652	9.706	9.886	9.618	10.233	10.357	7.999	10.862	11.186	9.984	13.159	9.470
Slip, in knots per hour ...	2.152	2.104	0.951	1.120	1.450	2.029	-0.601	8.120	2.686	2.778	8.859	1.270
Slip per cent. ...	22.30	21.68	9.62	11.64	14.17	19.59	-7.51	28.72	24.01	27.82	29.33	13.41
Speed ³ × $\frac{1}{D}$ ÷ indicated horse-power ...	351.9	506.9	481.5	500	423.2	583.2	461.4	284.6	438	297.3	543.5	447.8
Speed ³ × $D^{\frac{2}{3}}$ ÷ indicated horse-power ...	98.8	...	149.4	...	118.3	...	...	...	...	83.3	...	120.1
Wind ...	...	No. 2.	No. 3.	...	...	...	...	No. 7, very strong.	Fresh breeze.	...	Calm.	Light breeze.
Sea ...	...	...	...	...	...	...	...	...	Consider- able swell.	...	Smooth.	Smooth.
Remarks ...	...	...	...	...	...	Fully rgd. and com- plete with sea stores.	Launch- ing, letts not re- moved.	...	...	...	...	...
Reference to Reports ...	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862

TABLE V.—MEN-OF-WAR (GROUP 3).

Groups of a Speed	3. Between 9 and 11 knots.															
Subgroups of Displacement	A. Under 125 tons.	C. Between 250 and 500 tons.										D. Between 500 and 1000 tons.				
	Dwarf.	Dart.	Lee.	Snipe.	Sparrow.	Nimble.	Mullet.	Espoir.	Griffon.	Snake.	Sharp- shooter	Beagle.	Ranger.	Philomel.	Gannet.	Cordelia.
Length in water-line, in feet... ..	130	145	145	145	145	145	145	145	145	160	150	160	145	145	151	151
Breadth (extreme), in feet	16.5	25.33	25.33	25.33	25.33	25.33	25.33	25.33	25.33	25.33	26.61	25.33	25.33	25.33	29.08	29.08
Tonnage, builder's measurement ...	164	425	425	425	425	425	425	425	425	477	503	477	425	425	577	577
Mean draught of water, in feet ...	5.5	9.08	9.12	9.16	9.20	9.25	9.24	9.45	9.46	9.62	9.25	10.125	11.33	11.58	10.87	11
Area of immersed midship sectn., sq. ft.	44	166	167	168.5	169.5	170.5	170.5	176	176	179	196	192	223	230	202	204
Displacement, in tons of 35 cubic feet	98	390	392.5	395	398	401	401	416	416	482	518	523	550	570	583	591
ENGINES.																
Description	Vert.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	H. trunk.	Hor.	Hor.	H. sing. T	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches ...	40	32	32	32	32	30	32	30	32	32.125	=35.1	46	42.125	=30.2	32	39
Length of stroke, in feet	2.67	1.5	1.5	1.5	1.5	1.67	1.5	1.67	1.5	1.67	3	1.75	1.5	1.5	2	2
Number of revolutions, per minute ...	35.5	101	98	103	108	100	102	98	101	109.83	41.5	72	95.5	108	90.6	78
Weight per square inch on safety- valve in pounds	8	20	20	20	20	20	20	20	20	20	10	20	20	20	20	20
Nominal horse-power... ..	90	80	80	80	80	80	80	80	80	160	200	160	80	80	150	150
Indicated horse-power	216	361.7	343.1	363.4	391.8	334	355.4	330.3	325.9	459.8	365.2	295	283.6	354.2	616.6	460.8
PROPELLER.																
Diameter, in feet	5.67	9	9	9	9	9	9	9	9	11	9	11.08	9	9	10	10
Pitch, in feet	8	12.33	12.33	12.33	12.33	11.75	12.33	11.75	12.33	10	9	14.71	11.5	12.18	14.5	16
Length in line of shaft	1	2	2	2	2	2	2	2	2	2.33	1.5	2.29	1.83	2.21	2.5	2.5
Immersion at bottom, in feet... ..	...	4.67	5	5.25	5.33	4.67	5.16	4.83	5	3.67	...	4.42	6	6.42	4.5	5.67
Number of revolutions, per minute ...	182.8	101	98	103	108	100	102	98	101	109.83	124.5	72	95.5	108	90.6	78
Speed of ship, in knots per hour ...	10.537	10.19	10.022	10.32	10.872	9.933	10.067	10.05	10.119	10.308	9.189	9.409	9.006	9.548	10.817	9.912
Speed of propeller	14.427	12.287	11.922	12.531	13.189	11.590	12.409	11.359	12.287	10.834	11.052	10.446	10.833	13.032	12.958	12.310
Slip, in knots per hour	3.890	2.097	1.900	2.211	2.267	1.657	2.342	1.809	2.168	0.531	1.863	1.037	1.827	8.484	2.141	2.398
Slip, per cent... ..	26.96	17.07	15.94	17.64	17.25	14.30	18.87	11.52	17.64	4.90	16.85	9.93	16.86	26.73	16.52	19.48
Speed ² × $\frac{1}{D^2}$ ÷ indicated horse-power ...	238.3	485.6	490	509.7	555.9	500.3	489.5	540.9	559.6	425.8	416.4	542.1	574.4	565.2	414.6	431.2
Speed ² × $\frac{1}{D^2}$ ÷ indicated horse-power..	...	156.2	157.2	162.8	177.5	159.6	156.1	171.3	177.2	146.2	...	183.3	172.9	168.9	143.3	148.8
Wind	...	...	...	...	...	...	...	No. 5	No. 4 to No. 5	...	...	No. 1 to No. 2	No. 3 to No. 4	No. 3 to No. 4	Calm.	Light breeze.
Sea	...	...	...	...	...	...	...	Smooth	...	...	...	...	...	...	Smooth.	Little swell.
Remarks	Not rigged.	...	...	...	...	...	...	...	...	...	Rigd. and partially equipped.	...	...	Rigged and stored.	...	...
Reference to Reports	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862

Groups of a Speed	8. Between 9 and 11 knots.															
	D. Between 500 and 1000 tons.															
Subgroups of Displacement																
Name of Vessel	Alacrity	Icarus.	Eclipse.	Lily.*	Surprise.	Wanderer.	Rosario.	Rapid.	Coquette.	Fawn.	Ringdove.	Race-horse.	Alert.	Lapwing.	Mohawk.	Vigilant.
Length in water-line, in feet... ..	180	151	185	185	180	180	160	160	180	160	180	185	160	180	180	180
Breadth (extreme), in feet	28.33	29.08	28.33	28.33	28.33	28.33	30.33	30.33	28.33	31.33	28.33	28.33	31.33	28.33	28.33	28.33
Tonnage, builder's measurement ...	670	577	695	695	670	670	669	669	670	748	670	695	748	670	670	670
Mean draft of water, in feet... ..	9.25	11	9.33	9.33	9.5	9.57	11.5	11.71	11.41	11.33	10.21	10.16	11.41	10.83	10.87	11.04
Area of immersed midship sect., sq. ft.	195	211	198	200	203.5	206	222	228	242	247	223	221	250	240	242	245.5
Displacement, in tons of 35 cubic feet	605	618	625	634	637	645	646	666	790	709	714	718	718	781	785	803.5
ENGINES.																
Description	Hor.	H. sin. Tr.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches ...	45	38.875	45	45	45	45	38	38	45	32	45	45	32	45	42.25	45
Length of stroke, in feet	2	1.83	2	2	2	2	2	2	2	2	2	2	2	2	2.16	2
Number of revolutions per minute ...	85.5	92	96	76	92	88.5	98	100	82.25	92.5	84	85	92	85	88	84
Weight per sq. in. on safety-valve, in pounds	20	20	20	20	20	20	24	20	20	20	20	20	20	20	20	20
Nominal horse-power... ..	200	150	200	200	200	200	150	150	200	100	200	200	100	200	200	200
Indicated horse-power	587.2	602.8	838.4	474.1	721.4	627.8	615.2	618	690	406.9	676.8	731.6	387.4	689.2	641.5	629.9
PROPELLER.																
Diameter, in feet	11	10	11	11	11	11	10	10	11	10	11	11	10	11	11.08	11
Pitch, in feet	16	14.42	16.5	17	15.83	16.54	14	13	16	12	15.71	16.5	12	15.65	14.25	16.46
Length in line of shaft	2.5	2.19	2.42	8.25	2.5	2.67	2.5	3	2.5	2	2.5	2.46	2	2.5	2.56	2.64
Immersion at bottom, in feet... ..	3.42	5.67	3.92	4.83	3.92	3.5	5.33	5.75	4.57	5.83	4.16	4.67	5.25	4.42	4.42	4.57
Number of revolutions, per minute ...	85.5	92	96	76	98	88.5	98	100	82.25	92.5	84	85	92	85	88	84
Speed of ship, in knots per hour ...	10.651	10.146	11	10	10.81	10.258	10.08	10.2	10.853	9.21	10.824	10.937	9.607	11.021	10.721	9.763
Speed of propeller	13.494	13.083	15.625	12.744	14.525	14.440	12.843	12.823	12.981	10.949	13.016	13.834	10.890	13.101	12.870	13.257
Slip, in knots per hour	2.843	2.937	4.625	2.744	3.715	4.182	2.763	2.623	2.128	1.739	2.192	2.897	1.288	2.080	1.649	8.494
Slip, per cent... ..	21.07	22.45	29.60	21.53	25.58	28.96	21.51	20.45	16.39	15.88	16.84	20.94	11.78	15.88	18.33	26.86
Speed ² × $\frac{1}{D^2}$ ÷ indicated horse-power	401.3	365.6	313.60	421.8	356.3	354.2	369.6	394.6	448.3	474.3	417.8	395.2	572.1	466.2	464.9	362.7
Speed ² × $\frac{1}{D^2}$ ÷ indicated horse-power	147.2	125.7	116.1	155.7	129.6	128.4	124.4	132	...	152.7	...	143.4	183.5	...	...	127.7
Wind	...	...	...	...	...	No. 3.	...	...	No. 3.	...	No. 1.	No. 3 to No. 4.	Light	No. 2.	No. 2 to No. 3.	No. 5 to No. 6.
Sea	...	...	...	...	Smooth.	...	...	...	...	...	...	...	Smooth.	...	...	...
Remarks	...	...	...	...	...	...	...	...	...	...	...	...	Without masts or rigging.	...	...	Steam main- tained at not more than 18 lb.
Reference to Reports	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862

* Half boiler power.

TABLE V. (continued).

Groups of a Speed ...	3. Between 9 and 11 knots.																
	D. Between 500 and 1000 tons.					E. Between 1000 and 2000 tons.											
	Osprey.	Racer.	Victor.	Indus-try.	Zebra.	Intrepid.	Rattler.	Chame-leon.	Flying Fish.	Grey-hound.	Mutine.	Rinaldo.	Fox.	Miranda.	Tartar.	Brisk.	En-counter.
Length in water-line, in feet	180	151	200	179.5	185	200	176.5	185	218	172.5	172.5	185	159.33	196.04	195	193.57	190
Breadth (extreme), in feet	28.33	29.08	30.16	27.12	33.16	30.16	32.71	33.16	30.33	33.16	33.16	33.16	40.33	34	38.5	35	43.20
Tonnage builder's measurement	670	577	851	638	950	851	888	950	950	878	950	1131	1039	1039	1322	1074	953
Mean draft of water in ft.	11.20	13.37	10.04	12.66	11.83	11.29	13.79	13.54	11.92	13.78	14	14.62	16.29	12.37	13.96	13.75	13.70
Area of immersed midship section, square feet	250.5	272	233	281	277	270	338	332	286	342	349	367.4	449	336	379	350	382
Displacement, in tons of 35 cubic feet	826.5	829	875	903	912	1040	1112	1138	1161	1175	1200	1286	1340	1350	1350	1370	1459
ENGINES.																	
Description ...	Hor.	Hor.	Hor.	Oscil.	Hor.	Hor.	V. d. c. g.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	H. geared	Hor.	Hor.	H. trunk.
Number of cylinders	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in in.	45.06	40	55	36.5	42.5	58.06	40.125	45	58.06	45	45	42.5	45	56.375	51	52	=55
Length of stroke, in feet	2	1.67	2.5	3	2.16	2.25	4	2	2.25	2	2	2.16	2	3.75	2.25	3.5	2.25
Number of rev. per minute	80	96.5	84.5	42	112	70	25.43	80.8	74.5	80.5	82	92.083	93	28.5	72.25	39	81.75
Weight per square inch on safety-valve, in pounds	20	22	20	12	20	20	10	20	20	20	20	20	20	13	14	14	12
Nominal horse power	200	150	350	100	200	350	200	200	350	200	200	200	200	250	250	250	300
Indicated horse power	593.4	522.2	973.8	317.8	984.8	930.1	519.2	584.2	1222.6	744.9	786.4	752.4	740.8	613.1	731	595.6	844
PROPELLER.																	
Diameter, in feet	11.04	10	11	9	12	11	10	12.33	13.16	12.33	12.33	12	12.04	12	12.08	12	12
Pitch, in feet	15.83	13.5	20.5	11	15	21.25	11	13.5	19.96	14.5	13.87	10.86	11.5	16.5	12.16	15.75	15.75
Length in line of shaft	2.59	2.19	3	1.83	2.75	3.02	1.25	2.29	8	2.42	2.67	2.12	2	1.92	2.75	2	2.67
Immersion at bottom, in ft.	4.5	6.92	4.16	6.92	4.25	5.16	7.5	5.33	5.75	5.67	6.16	7.33	9.42	5.25	6.16	6.33	6.54
Number of rev. per minute	80	96.5	84.5	97.548	112	70	101.72	80.8	74.5	80.5	82	92.083	93	87.87	72.25	87.75	81.75
Speed of ship in knots per hr	10.15	9.519	9.056	9.12	10.714	10.25	9.141	10.206	12.43	9.87	10.25	10.588	9.325	10.75	9.4	9.035	10.699
Speed of propeller	12.495	12.85	17.087	10.585	16.572	14.673	10.037	10.742	14.667	11.448	10.92	12.603	10.884	9.968	11.759	10.531	12.735
Slip, in knots per hour	2.345	3.331	8.031	1.465	5.858	4.423	1.896	0.536	2.237	1.578	0.67	2.015	1.559	-0.782	2.359	1.496	2.036
Slip, per cent.	18.77	25.92	47	13.84	35.35	30.14	17.18	4.99	15.25	13.78	6.14	15.99	14.32	7.85	20.06	14.21	15.99
Speed ³ × $\frac{\pi}{4} \div$ I. H. P.	441.4	449.3	177.7	670.8	345.9	312.6	497.2	603.3	448.5	441.4	477.9	579.6	491.5	680.8	430.6	433.4	554.3
Speed ³ × $\frac{\pi}{4} \div$ I. H. P.	155.2	145.8	69.8	223.1	117.4	118.9	...	198.4	173.5	143.7	154.6	186.6	133	...	138.8	152.8	...
Wind	...	...	No. 3.	...	...	...	...	Light.	No. 2.	Light.	...	No. 3.	No. 3.	No. 5 abeam.	No. 5 to No. 6.	No. 4 to No. 5.	Calm.
Sea	...	...	...	...	...	Smooth.	...	...	...	Smooth.	...	...	...	...	...	...	...
Remarks	...	...	Bottom foul.	...	...	...	...	...	...	...	...	Fully equipped for sea.	...	...	...	...	Fully rigged.
Reference to Reports	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862

Groups of a Speed			3. Between 9 and 11 knots.															
			E. Between 1000 and 2000 tons.							F. Between 2000 and 4000 tons.								
Subgroups of Displacement			Niger.	Magara.	Despe- rate.	Terma- gant.	High- flyer.	Seahorse.	Esk.	Gree- nock.	Pylades.	Chal- lenger.	Pearl.	Raccoon.*	Satellite.	Satellite.*	Tribune.	Assist- ance.
Name of Vessel																		
Length in water-line, in feet			194.33	207	192.33	210.08	192	159	192	213	192.75	200	200	200	200	200	192	282.87
Breadth (extreme), in feet			34.67	37.83	34.35	40.5	36.33	41.83	36.25	37.40	38.42	40.33	40.33	40.33	40.33	40.33	43	36.39
Tonnage, builder's measurement			1072	1395	1037	1547	1153	1212	1169	1418	1278	1462	1462	1462	1462	1462	1570	1793
Mean draft of water in feet			15.79	13.29	15.96	14.05	16.5	18.21	16.87	14.20	17.5	17.43	17.92	17.96	18.08	18.08	18.5	16.62
Area of immersed midship sec- tion, square feet			437	383	452	436	476	518	488	419	522	522	538	540	546	546	578	440
Displacement, in tons of 35 c. ft.			1497	1554	1663	1670	1775	1799	1835	1835	1956	2018	2107	2115	2138	2138	2220	2260
ENGINES.																		
Description			Hor.	Hor.	H. geared	Hor.	Hor.	H. T. H. P.	In. oscil.	Hor.	H. trunk.	H. trunk.	H. trunk.	Hor.	H. trunk.	H. trunk.	Hor.	H. S. Tr.
Number of cylinders			4	4	4	2	2	2	2	2	2	2	2	2	2	2	2	4
Diameter of cylinders, in inches			47.625	49.5	55.01	62.5	55.18	=30.25	50	71	=55	=58.11	=58.11	64	=58.11	=58.11	55	=45.16
Length of stroke, in feet			1.83	2	2.5	3	2.5	2.5	2.75	4	3	3.25	3.25	3	3.25	3.25	2.5	3
Number of revolutions per minute			78	74.21	37	62	53.37	112.25	68	32	62.5	54.6	55.25	56	57	47.5	72.5	45.083
Weight per square inch on safety- valve, in pounds			12	8	10	15	...	60	18	...	20	20	20	20	20	20	20	12
Nominal horse power			400	350	400	400	250	200	250	564	350	400	400	400	400	400	300	400
Indicated horse power			1002.1	925.6	891.7	1205.6	702	832.4	721	719.3	1106	1190.8	1078.1	1485	1213.5	700.4	1068	878.8
PROPELLER.																		
Diameter, in feet			12.5	14.46	13.08	15.61	12.06	12	12.20	14	15.75	16	16	16	16	16	14.08	17.18
Pitch, in feet			17.25	16	13.83	24	9.71	10	17.5	13	20	23.5	=22.92	26	23.5	23.5	17.57	22.62
Length in line of shaft			2.45	2.73	2.25	2.87	1.67	1.67	...	2.16	3	3	3	3	3	3	2.87	2.75
Immersion at bottom, in feet			8.25	6.67	8.42	5.5	8.33	11.08	8.75	...	8.83	7.67	8.83	8.92	8.92	8.92	9.83	7.67
Number of revolutions, per min.			78	74.21	80.727	62	106.74	112.25	68	75.2	62.5	54.6	55.25	56	57	47.5	72.5	54.083
Speed of ship, in knots per hour			10.25	10.241	9.6	10.66	9.399	9.298	9.25	9.59	10.119	10.601	10.988	10.918	10.55	9.366	10.418	10.663
Speed of propeller			13.272	11.711	11.016	14.678	10.222	11.072	11.738	9.643	12.330	12.656	12.49	14.362	13.213	11.011	12.575	12.075
Slip in knots per hour			3.022	1.470	1.416	4.018	0.823	1.774	2.488	0.053	2.211	2.055	1.502	3.444	2.663	1.645	2.157	1.412
Slip, per cent.			22.77	12.55	12.85	27.37	8.05	16.02	21.20	0.54	17.93	16.24	12.03	23.98	20.15	14.94	17.15	11.69
Speed ³ × $\frac{\pi}{4}$ ÷ indicated H. P.			469.6	444.4	448.5	438.1	563	500.2	535.7	513.8	489	521.8	662	473	528.3	640.5	611.9	607
Speed ³ × $\frac{\pi}{4}$ ÷ indicated H. P.			140.6	...	139.3	141.4	...	...	...	...	...	159.8	202.2	144.3	160.6	194.7	...	237.6
Wind			...	...	Light breeze.	No. 4.	...	No. 3.	...	...	...	No. 5 to No. 6.	No. 2.	No. 3 to No. 4.	Fresh breeze.	Fresh breeze.	No. 2.	No. 2 to No. 3.
Sea			...	...	Smooth.	...	...	...	...	...	...	...	...	...	Little swell.	Little swell.	...	...
Remarks			...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reference to Reports			...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Half boiler power.

TABLE V. (continued).

Groups of a Speed ...	3. Between 9 and 11 knots.															
Subgroups of Displacement ...	F. Between 2000 and 4000 tons.															
Name of Vessel ...	Ad-venture.	Vulcan.	Lion.	Simoon.	Phoebe*	Goliath.	Phaeton.	Colossus.	Im- périeuse.	London.	Aboukir.	Nelson.	Windsor Castle.	Cæsar.	Royal George.	Cheza- re.k.
Length in water-line, in feet ...	282.87	220	192	246	240.5	190	220.26	190	212	215.25	204	216.25	204	207.33	205.57	212
Breadth (extreme), in feet ...	36.37	41.42	57	41	51.5	56.75	49.83	57	50	54.29	60	54.5	60.04	56.06	54.54	50
Tonnage, builder's measurement ...	1793	1764	261	1980	2848	2590	2396	2590	2355	2687	8091	2736	3101	2767	2616	2356
Mean draft of water, in feet ...	17.21	17.20	19.75	15.95	17.95	20.04	19.87	21.04	20.49	19.83	20.5	19.66	20.25	21.04	20.17	21.66
Area of immersed midship sec., square feet ...	461	553	635	528	578	684	657	708	688	735	740	750	770	726	760	746
Displacement, in tons of 35 c. ft.	2388	2520	2540	2550	2700	2737	2840	2855	3044	3115	3150	3158	3245	3250	3270	3334
ENGINES.																
Description ...	H. S. Tr.	Hor.	H. trunk	Hor.	Hor.	H. trunk.	Hor.	H. trunk.	H. truck.	Hor.	H. trunk.	Hor.	H. trunk.	H. trunk.	H. trunk.	Hor.
Number of cylinders ...	4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches ...	=45.16	64	=58.11	62.5	65	=58.11	64	=58.25	=55	70.07	=58.25	71	=64.83	=58	=58.11	64
Length of stroke, in feet ...	3	3	3.25	3	3	3.25	3	3.25	3	3	3.25	3	3.33	3.25	3.25	3
Number of revolutions per min.	51.75	48.375	66	57	50.5	60	57.33	61.83	68	49	62.3	54.66	68.5	60	60.33	52
Weight per sq. in. on safety- valve, in pounds ...	10	10	20	20	20	20	23	20	20	20	20	20	20	22	20	20
Nominal horse power ...	400	400	400	400	500	400	400	400	360	500	400	500	500	400	400	400
Indicated horse power ...	824.9	857.3	1771.2	1255.3	844.3	1437.5	1566.2	1420.6	1199.8	878.7	1533	1190.8	2052.3	1420	1397.9	1159.2
PROPELLER.																
Diameter, in feet ...	17.18	17.08	17	15.92	18	18.5	17	17.12	15.96	18	17	18	17	17.12	17	17
Pitch, in feet ...	22.62	22.87	18.5	24.57	22	17	24	18.46	17	20	17.5	20.16	18.5	18.89	18	22.5
Length in line of shaft ...	2.75	3	3	2.71	3.25	3	3	2.89	2.61	3	3	3.75	3	2.96	3	3
Immersion at bottom, in feet ...	8.33	10.67	10.42	8.08	7.5	10.57	10	10.42	11.25	9.88	10.16	9.83	10.75	11.42	10	11.75
Number of revolutions, per min.	51.75	48.375	66	57	50.5	60	57.33	61.83	68	49	62.3	54.66	68.5	60	60.33	52
Speed of ship, in knots per hour ...	10.316	9.511	10.911	10.861	9.959	9.16	10.466	9.66	10.111	9.508	9.55	10.363	10.955	10.274	9.568	9.658
Speed of propeller ...	11.555	10.915	12.044	18.822	10.959	10.949	13.573	11.258	11.408	9.667	10.754	10.875	12.503	11.183	10.712	11.541
Slip, in knots per hour ...	1.239	1.404	1.133	2.961	1	1.789	3.107	1.598	1.292	0.159	1.204	0.512	1.548	0.909	1.144	1.883
Slip, per cent. ...	10.72	12.86	9.41	21.42	9.12	16.34	22.89	14.19	11.33	1.64	11.20	4.71	12.38	8.18	10.68	16.32
Speed ³ × D ⁵ ÷ ind. horse power ...	618.5	554.9	465.7	588.9	670.8	365.7	480.9	485.4	592.7	719	420.4	700.9	498.3	554.5	476.2	579.8
Speed ³ × D ⁵ ÷ ind. horse power ...	237.8	185.8	136.5	190.5	226.8	104.6	146.8	134.9	181	208.6	122.1	201.2	140.4	...	188	173.4
Wind ...	No. 4.	No. 5 to No. 6.	Light breeze.	No. 5 to No. 6.	No. 4	No. 3.	No. 5 to No. 6.	...	No. 4.	No. 4.	No. 7 to No. 8.	No. 3.	No. 4.	No. 1.	Calm.	No. 4 to No. 5.
Sea ...	...	...	Little swell.	...	Moderate swell.	...	...	...	...	Little swell.	Heavy swell.	...	...	...	Smooth.	...
Remarks ...	...	Supply of steam deficient.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reference to Reports ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Half boiler power.

Groups of a Speed ...	3. Between 9 and 11 knots.															
Subgroups of Displacement ...	F. Between 2000 and 4000 tons.								G. Between 4000 and 8000 tons.							
Name of Vessel ...	Nar- cissus.	Royal William.	Algiers.*	Immor- talité.	Tra- falgar.	Queen.	Ex- mouth.	Saint George.	Orion.	Neptune.	Agamemnon.	Duke of Wel- lington.	*Victor Emanuel.	Victor Emanuel.	James Watt.	Renown.*
Length in water-line, in feet ...	228	216.75	218.57	251	216	214	204	216.5	238	216.5	230	240.5	230	230	230	244.75
Breadth (extreme), in feet ...	51.25	55.75	60	52.08	55.46	60	60	54.37	55.75	55.42	55.33	60	55.33	55.33	55.42	55.33
Tonnage (builder's measurement) ...	2665	2849	3347	3059	2900	3249	3083	2864	3232	2830	3074	3759	3087	3087	3083	3318
Mean draft of water, in feet ...	21.42	21.04	21	21.42	22.91	22.79	24.37	23.95	24.12	24.96	23.04	23.62	24.12	24.12	24.33	23.67
Area of immersed midship section, square feet ...	706	820	814	715	880	910	968	966	894	1018	1012	988	1065	1065	1085	1050
Displacement, in tons of 35 cub. ft.	3412	3520	3550	3625	3850	3930	4300	4313	4580	4589	4806	5080	5106	5106	5226	5320
ENGINES.																
Description ...	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	H. trunk.	Hor.	H. trunk.	H. geared.	Hor.	Hor.	Hor.	H. trunk.
Number of cylinders ...	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	2
Diameter of cylinders, in inches ...	64	65	76.125	76	66	66	64	71	=70.75	71	70.75	93.87	76.125	76.125	52.25	=82
Length of stroke, in feet ...	3	3	3.5	3.5	3.5	3.5	3	3	3.5	3	3.5	4.5	3.5	3.5	3	4
Number of revolutions, per min.	63.5	62.5	47.75	46	62.166	63.83	53	59.5	54	63.5	60.58	29.5	45.75	56.75	=52	43.5
Weight per square inch on safety- valve, in pounds ...	20	20	20	20	20	20	20	20	20	20	20	15	20	20	16	20
Nominal horse power ...	400	500	600	600	500	500	400	500	600	500	600	700	600	600	600	800
Indicated horse power ...	1701.1	1763.1	1361.8	1337.7	2275.1	2282.6	1252.4	1730.4	1956.7	2002.5	1948.5	1979	1273.8	2423.8	1531	1427
PROPELLER.																
Diameter, in feet ...	17	18	18.12	19.42	18	18	17	18	18	18	18	18	18.16	18.16	17	19
Pitch, in feet ...	18.5	20	26.08	25.5	19	19	21	20	23	19.75	21.83	16.25	26.16	26.16	24	28
Length in line of shaft ...	3.57	3	3	3.39	3.04	3.5	3.03	3	3.16	3	3.33	2.81	3.08	3.08	3	3.5
Immersion at bottom, in feet ...	11.67	10.42	10.75	9.5	11.33	11.5	13.42	12.57	12.25	14.42	13.33	11.92	12.83	12.83	13	11.16
Number of revolutions, per min.	63.5	62.5	47.75	46	62.166	63.83	53	59.5	54	63.5	60.58	29.5	45.75	56.75	52	43.5
Speed of ship, in knots per hour ...	10.936	10.581	10.487	10.94	10.908	10.578	9.1	10.933	10.1	10.897	10.717	10.15	9.072	10.874	9.5	9.145
Speed of propeller ...	11.588	12.330	12.286	11.571	11.651	11.963	10.979	11.738	12.251	12.371	13.048	10.675	11.809	14.648	12.310	12.014
Slip, in knots per hour ...	0.652	1.749	1.799	0.631	0.743	1.385	1.879	0.805	2.151	1.474	2.331	0.524	2.737	3.774	2.810	2.869
Slip, per cent. ...	5.63	14.18	14.64	5.45	6.38	11.58	17.11	6.86	17.56	11.92	17.87	4.92	23.18	25.76	22.83	23.88
Speed ³ × D ⁵ ÷ ind. horse power ...	542.8	550.9	547.6	699.8	502	471.9	582.4	729.6	470.7	657.8	639.3	522	624.2	564.9	607.6	562.8
Speed ³ × D ⁵ ÷ ind. horse power ...	174.3	155.5	156.6	231	140.1	129.1	159.1	200.1	145.2	178.4	179.9	...	173.8	157.3	168.6	163.3
Wind ...	Light breeze.	Light breeze.	No. 4.	No. 2.	Calm.	No. 6.	...	No. 5.	Light breeze.	No. 2 to No. 3.	No. 4 to No. 5.	No. 4.	No. 4.	No. 4.	Light.	No. 4.
Sea ...	Little swell.	Little swell.	Slight wave.	...	Smooth.	Disturb. sea.	...	Moderate swell.	Smooth.	...	...	...	...	...	Smooth.	...
Remarks ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reference to Reports ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Half boiler power.

TABLE VI.—MEN-OF-WAR (GROUP 4).

Groups of a Speed	4. Between 11 and 13 knots.															
	C. Between 250 and 500 tons.			D. Between 500 and 1000 tons.										E. Between 1000 and 2000 tons.		
	Cygnet.	Steady.	Penguin.	Arrow.	Fox-hound.	Lily.	Serpent.	Star.	Cormorant.	Sparrow-hawk.	Assurance.	Pelican.	Roe-buck.	Pioneer.	Scout.	Pelorus.
Length in water-line, in feet...	145.08	145	145	160	180	185	185	185	185	180	180	185	200	200	200	200
Breadth (extreme), in feet ...	25.42	25.33	25.33	25.33	28.33	28.33	28.33	28.33	28.33	28.33	28.33	33.16	30.16	30.33	40.33	40.33
Tonnage, builder's measurement ...	428	425	425	477	670	695	695	695	695	670	670	950	851	868	1462	1462
Mean draft of water, in feet ...	9.14	9.33	9.37	10.83	9.17	9.83	9.42	9.62	10.16	10.83	10.83	11.89	10.49	10.91	14.37	14.83
Area of immersed midship sec., sq. ft.	168	173	174	209	194	200	200	206	221	240	240	279	246	262	399	417
Displacement, in tons of 35 cubic feet	393	407	410	586	601	634	634	657	718	781	781	920	935	1010	1478	1558
ENGINES.																
Description	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	H. trunk.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches ...	32	32	32	42	42	45	45	45	45	42.25	45	45	55	55	58.11	64
Length of stroke, in feet	1.5	1.5	1.5	1.75	2.16	2	2	2	2	2.16	2	2	2.5	2.5	3.25	3
Number of revolutions per minute ...	110	106	107	93	94	90	102	102	85	92	87	89.75	95.833	82	66	57
Weight per square inch on safety-valve, in pounds	21	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Nominal horse-power	80	80	80	160	200	200	200	200	200	200	200	200	350	350	400	400
Indicated horse-power	354.2	360.4	364.6	594	599.5	799.1	907.3	892.3	722.8	725.6	744	758.5	1277.9	1150	1421.6	1437.6
PROPELLER.																
Diameter, in feet	9	9	9	11.04	11	11	11	11	11	11	11	12	11.08	11	15.94	16
Pitch, in feet	12.01	12.33	12.33	13	15	17	16.5	16.5	16.5	14.25	16	14.13	20.42	20.5	23.5	26
Length in line of shaft	1.97	2	2	2.30	2.54	3.25	2.46	2.42	2.46	2.58	2.5	2.42	3	3	3	3
Immersion at bottom, in feet ...	4.96	4.5	4.5	4.57	3	4.83	3.67	3.92	4.42	4.33	4.25	4.67	4.42	5	5.16	6.25
Number of revolutions per minute ...	110	106	107	93	94	90	102	102	85	92	87	89.75	95.833	82	66	57
Speed of ship, in knots per hour ...	11.233	11.053	11.078	11	11.6	11.48	11.056	11.1	11.155	11.065	11.142	11.666	11.144	11.332	11.6	11.93
Speed of propeller	13.032	12.896	13.017	11.926	13.908	15.092	16.601	16.601	13.834	12.932	13.731	12.514	19.300	16.582	15.299	14.619
Slip, in knots per hour	1.799	1.843	1.939	0.926	2.308	3.612	5.545	5.501	2.679	1.867	2.589	0.848	8.156	5.250	3.699	2.689
Slip, per cent.	13.80	14.29	14.90	7.76	16.59	23.93	33.40	33.14	19.36	14.44	18.86	6.78	42.26	31.66	24.18	18.39
Speed ³ × $\frac{\pi}{4} \div$ indicated horse-power	672.3	648.2	648.9	468.3	505.1	578.6	297.9	315.7	424.4	448.1	445.8	584	266.4	331.5	438.1	492.5
Speed ³ × $D^2 \div$ indicated horse-power	214.7	205.8	205.8	...	185.4	139.7	109.9	115.8	154	...	...	198	103.6	...	142.5	158.7
Wind	No. 2	...	...	...	...	...	...	...	No. 2.	No. 2 to No. 3.	Calm.	Calm.	No. 4 to No. 5.	No. 6 on the beam.	...	Light breeze.
Sea	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Smooth.
Reference to Reports	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862

Groups of a Speed	4. Between 11 and 13 knots.															
	E. Between 1000 and 2000 tons.					F. Between 2000 and 4000 tons.										
	Clio.	Char-ybdis.	Orpheus.	Orestes.	Barossa.	Cadmus.	Racoon.	Jason.	Perseverance.	Urgent.	Forte.	Transit.	Severn.	Phoebe.	Melpomene.	Emerald.
Length in water-line, in feet ...	200	200	225	225	225	200	200	225	272.58	273.90	212	800	240.5	240.5	237	237
Breadth (extreme), in feet ...	40.33	40.33	40.67	40.67	40.67	40.33	40.33	40.67	38.5	38.54	50.08	41.5	50	51.5	52	52
Tonnage, builder's measurement ...	1462	1462	1702	1702	1702	1462	1462	1702	1967	1981	2364	2522	2712	2848	2852	2852
Mean draft of water, in feet ...	14.87	14.92	15.25	15.49	15.83	17.71	18.87	18.5	18.04	18.37	17.74	18	18.57	17.95	18.53	18.91
Area of immersed midship section, square feet ...	419	421	443	453	466	537	558	575.5	500.5	513	550	528.5	536	573	568	586
Displacement, in tons of 35 c. ft.	1585	1572	1672	1720	1780	2065	2192	2294	2299	2370	2370	2628	2688	2700	2741	2835
ENGINES.																
Description	Hor.	Hor.	Hor.	Hor.	Hor.	Hor. T.	Hor.	Hor.	Hor. T.	Hor.	Hor.	Hor. T.	Hor.	Hor.	Hon. T.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches ...	64	64	64	60.75	64	58.11	64	64	55	64	64	58.5	66	65	70.75	76
Length of stroke, in feet	3	3	2.67	3	3	3.25	3	3	3	3	3	3.25	3.5	3	3.5	3.5
Number of revolutions, per min.	57.83	61.5	65	65	66	58.25	58.66	54.5	57.5	59.25	56.33	56.75	67.166	62	59	54
Weight per square in. on safety-valve, in pounds	20	20	20	20	20	20	21	20	16	15	20	15	20	20	20	20
Nominal horse-power	400	400	400	400	400	400	400	400	360	400	400	400	500	500	600	600
Indicated horse-power	1539.2	1580.6	1445.2	1521.6	1798.2	1424	1651.1	1649.2	911.8	1226.8	1538.9	1234.3	1977.6	1779.9	2171.4	2060.9
PROPELLER.																
Diameter, in feet	16	16	16	16	16	16	16	16	16.06	17	17	17	18	18	18.04	18
Pitch, in feet	26	26	23	23	24	28.5	26	26	21.97	22.33	22.5	24.25	20	22	25.02	28
Length in line of shaft	3	3	3.81	3.81	3	3	3	3	3.57	3.02	3.5	3	3	3	3.33	3.5
Immersion at bottom, in feet ...	6	4.83	6.16	6.08	6.57	8.33	9	9.67	8.5	9.42	7.5	8.67	7.5	7.5	7.08	7.83
Number of revolutions, per min.	67.83	61.5	65	65	66	58.25	58.66	54.5	57.5	59.25	56.33	56.75	67.166	62	59	54
Speed of ship, in knots per hour ...	11.96	11.752	12.449	12.265	11.92	11.294	11.416	11.632	11.297	11.996	11.485	11.909	12.182	11.9	12.486	12
Speed of propeller	14.831	15.773	14.747	14.747	15.625	18.503	15.046	18.977	12.460	12.858	12.503	15.575	13.251	13.455	14.562	14.915
Slip, in knots per hour	2.871	4.021	2.298	2.482	3.705	2.209	3.630	2.345	1.163	0.862	1.018	1.666	1.119	1.530	2.126	2.915
Slip, per cent.	19.36	25.49	15.58	16.83	23.71	16.36	24.13	16.78	9.33	6.70	8.14	12.27	8.44	11.230	14.60	19.54
Speed ³ × $\frac{\pi}{4} \div$ indicated H.P. ...	465.7	432.3	591.4	549.3	488.9	543.3	502.8	584.6	791.4	721.9	541.4	723.2	484	548.5	503.1	491.4
Speed ³ × $D^2 \div$ indicated H.P. ...	149.8	138.8	188.1	174.1	138.3	164.1	152.1	176.7	275.4	250.1	175	260.6	172.4	185.6	173.5	168
Wind	...	...	...	No. 5.	No. 2 to No. 3.	No. 4.	Calm.	No. 4.	Calm.	No. 2.	...	No. 4.	No. 4.	No. 4.	No. 3.	...
Sea	...	...	...	...	...	Smooth.	Smooth.	...	...	Smooth.	...	...	...	Mod. swell.	...	...
Remarks	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reference to Reports	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

TABLE VI. (continued).

Groups of a Speed	4. From 11 to 13 knots.														
Subgroups of Displacement	F. Between 2000 and 4000 tons.														
Name of Vessel	Irresist- ible.	Topaze.	London.	Rodney.	Nelson.	Frederick William.	Princess Royal.	Waterloo.	Hood.	Algiers.	Bac- chante.	Immor- talité.	Doris.	Hima- laya.	Diadem.
Length in water-line in feet	190	235	215.25	214.33	216.25	214	217	218.20	238	218.57	235	251	240	340.42	240
Breadth (extreme) in feet	56.75	50	54.29	54	54.5	60	58.12	55.33	55.75	60	50	52.08	48	46.14	48
Tonnage, builder's measurement	2642	2651	2687	2770	2736	3241	3129	2845	3232	3347	2651	3059	2479	3453	2489
Mean draft of water in feet	21.08	18.71	19.83	20.12	19.66	20.25	20.90	20.79	20.58	21.07	21	21.45	20.49	18.83	20.54
Area of immersed midship section, } square feet	708	635	735	737	750	770	805	807	697	819	750	717	732	652	763
Displacement in tons of 35 cubic } feet	2855	3000	3115	3126	3158	3245	3400	3440	3470	3562	3631	3638	3724	3857	3880
ENGINES.															
Description	Hor. T.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor.	Hor. T.	Hor.	Hor.	Hor.	Hor. T.	Hor. T.	Hor.
Number of cylinders	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	58.11	76	70.875	66	71	66	64.125	71	70.75	76.125	76	76	82	78	82
Length of stroke, in feet	3.25	3.5	3	3.5	3	3.5	3	3	3.5	3.5	3.5	3.5	4	3.5	4
Number of revolutions per min.	66	49	60.75	71.666	65.83	72.66	58	62	62	57.66	55	55	53.71	55	56.33
Weight per square inch on safety- } valve, in pounds	20	20	20	20	20	20	20	20	20	20	20	20	20	12	20
Nominal horse power	400	600	500	500	500	500	400	500	600	600	600	600	800	700	800
Indicated horse power	1668.5	2131.4	1804.1	2245.6	2101.8	2276.3	1491	1889.9	2385.3	2518.4	2490.1	2392	3005	1830	2978.5
PROPELLER.															
Diameter, in feet	17	19.33	18	18	18	18.12	17.08	18	18	18.12	19.33	19.42	20.08	18.08	18
Pitch, in feet	17	29	20	16.5	20.16	17.79	2.54	20	23	26.08	25.79	25.5	30	28	33.42
Length in line of shaft	3.33	3.5	3	3	3.75	3.22	3	3.75	3.16	3	3.25	3.89	4.20	4.75	3.57
Immersion at bottom, in feet	11.25	7.5	9.83	9.67	9.83	10.92	9.79	10.33	9.42	10.83	10.33	9.5	9.75	9.92	10.42
Number of revolutions per min.	66	49	60.75	71.666	65.83	72.66	58	62	62	57.66	55	55	53.71	55	56.33
Speed of ship, in knots per hour	11.01	12.16	11.522	11.479	11.533	11.776	11.031	11.329	11.752	12.191	12.074	12.538	12.158	12.5	12.003
Speed of propeller	11.068	14.017	11.985	11.583	13.096	10.124	12.324	12.231	14.066	14.835	13.993	13.894	15.894	15.191	18.568
Slip, in knots per hour	0.058	1.857	0.463	0.104	1.563	1.652	1.293	0.902	2.314	2.644	1.919	1.296	3.736	2.691	6.565
Slip, per cent.	0.52	13.25	3.86	0.90	11.93	16.32	10.49	7.37	16.45	17.82	13.71	9.37	23.51	17.71	35.36
Speed ² × D ÷ indicated H. P.	566.3	535.7	623.2	496.4	547.4	552.4	724.7	620.9	474.3	589.2	530.1	601.6	437.8	695.9	443
Speed ² × D ÷ indicated H. P.	161	175.5	180.8	144	157.1	157.2	...	175.3	156	167.8	167	197	143.4	262.5	143.4
Wind	No. 5 to No. 6	No. 4.	No. 1 to No. 2	No. 4.	No. 4.	No. 4.	No. 3 to No. 5.	No. 2 to No. 3.	No. 3.	No. 5.	No. 2 to No. 3.	No. 2 to No. 3.	No. 1 to No. 2.	Little breeze.	Calm.
Sea	Consid. swell.	Little swell.	...	...	...	...	...	...	Smooth.	Slight wave.	...	...	...	Smooth.	...
Remarks	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reference to Reports	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Groups of a Speed	...	...	...	...	4. From 11 to 13 knots.												
Subgroups of Displacement	...	...	...	...	G. Between 4000 and 8000 tons.												
Name of Vessel...	...	...	...	...	Royal Sovereign	Gibraltar.	Prince of Wales.	Anson.	Edgar.	Hero.	Howe.*	Donegal.	St. Jean d'Acre.	Revenge.	Renown.	Mersey.	Marl- borough.
Length in water-line, in feet	...	...	...	...	240.5	252	252	244.75	230.25	234.25	260	240	238	244.75	244.75	300	245.5
Breadth (extreme), in feet	...	...	...	...	60	58	60.16	55.33	55.33	55.33	61	55.33	55.33	55.33	55.33	52	61.20
Tonnage, builder's measurement	...	...	...	...	3759	3716	3994	3317	3086	3127	4236	3224	3200	3318	3318	3727	4000
Mean draft of water, in feet	...	...	...	...	20.54	20.25	20.42	20.16	22.42	22.70	21.62	23.16	24.25	24	24.33	22.57	26.25
Area of immersed midship section, sq. ft.	...	...	...	...	802	832	800	856	977	993	949	1004	1067	1065	1082	917	11.89
Displacement, in tons of 35 cubic feet...	...	...	...	...	4023	4120	4170	4190	4614	4765	4770	4960	5340	5446	55.20	5678	60.35
ENGINES.																	
Description	...	...	...	...	Hor.	Hor.	Hor. Tr.	Hor.	Hor.	Hor.	Hor. Tr.	Hor. Tr.	Hor. Tr.	Hor.	Hor. Tr.	Hor.	Hor.
Number of cylinders	...	...	...	...	2	2	2	2	2	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	...	...	...	...	82	82	=82	82	76	76	=92.5	=82	=70.75	82	=82	92	82
Length of stroke, in feet	...	...	...	...	4	4	4	4	3.5	3.5	4	4	3.5	4	4	4	4
Number of revolutions, per minute	...	...	...	...	54	59	57.4	59	54.83	56	45.75	52.5	61	54.5	56.5	57.66	54.66
Weight per sq. in. on safety-valve, in pounds...	...	...	...	...	20	20	20	20	20	20	20	20	20	20	20	20	20
Nominal horse power	...	...	...	...	800	800	800	800	600	600	1000	800	600	800	800	800	800
Indicated horse power	...	...	...	...	2795	3504.8	3852	3582.6	2474.5	2662.1	2186.7	2832.3	2136	3028.2	3182.6	3877.8	3054.3
PROPELLER.																	
Diameter, in feet	...	...	...	...	19.12	19	19.08	19	18	18	20	19	18	19	19	20	19
Pitch, in feet	...	...	...	...	27.52	27.5	29.27	27.5	25.5	25.5	28	28	21.67	25	28	29.42	27.25
Length in line of shaft	...	...	...	...	3.59	4.83	3.97	4.16	3.04	3.5	4.5	3.5	3.5	3.5	3.5	4.25	3.51
Immersion at bottom, in feet	...	...	...	...	9.08	10	10.16	7.67	10.16	11.67	9.25	11	13.25	11.67	12	11.42	14.5
Number of revolutions, per minute	...	...	...	...	54	59	57.4	59	54.83	56	45.75	52.5	61	54.5	56.5	57.66	54.66
Speed of ship, in knots per hour	...	...	...	...	12.253	12.48	12.569	12.984	11.371	11.35	11.161	11.912	11.199	11.53	11.815	12.796	11.217
Speed of propeller	...	...	...	...	14.659	16.005	16.573	16.005	13.792	14.086	12.636	14.500	13.037	13.440	15.605	16.728	14.692
Slip, in knots per hour	...	...	...	...	2.406	3.525	4.004	3.021	2.421	2.736	1.475	2.588	1.838	1.910	3.790	8.932	3.475
Slip, per cent.	...	...	...	...	16.41	22.03	24.16	18.89	17.55	19.42	11.67	17.85	14.10	14.21	24.29	23.51	23.65
Speed ² × D ÷ indicated horse power	...	...	...	...	527.7	461.4	473.9	523.1	580.5	545.4	603.4	599.2	701.6	539.1	506.7	495.5	549.4
Speed ² × D ÷ indicated horse power	...	...	...	...	166.4	142.5	153.5	158.7	164.7	155.5	180.2	173.6	...	158.6	161.9	172	153.2
Wind	...	...	...	...	No. 2.	Light breeze.	Calm.	No. 2 to No. 3.	Calm.	Light breeze.	No. 3 to No. 4.	Calm.	No. 1.	No. 6 to No. 7.	...	No. 2.	No. 2 to No. 3.
Sea	...	...	...	...	...	Smooth.	...	Smooth.	...	Smooth.	...	Smooth.	...	...	...	...	Smooth.
Remarks...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Reference to Reports	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Half-boiler power.

TABLE VII.—MEN-OF-WAR (GROUP 5).

Groups of a Speed	Between 13 and 15 knots.						
Subgroups of Displacement	F. Between 2000 and 4000 tons.				G. Between 4000 and 8000 tons.		
Names of Vessels	New Castle.	Sutlej.	Atlas.	Duncan.	Ariadne.	Howe.	Orlando.
Length between the perpendiculars	250	254.5	244.75	252	280	260	300
Breadth (extreme)	52	51.67	55.33	58	50	61	52
Tonnage	3027	3065	3317	3716	3214	4236	3727
Mean draft of water	17.20	18.70	19.37	19.83	21.33	21.61	21.87
Area of immersed	581	530	810	808	771	949	880
Displacement	2655	2760	3940	3985	4426	4770	5416
ENGINES.							
Description	Horizontal.	Horizontal.	Horizontal.	Horiz. trunk.	Horizontal.	Horiz. trunk.	Horiz. trunk.
Number of cylinders	2	2	2	2	2	2	2
Diameter of cylinders	76	66	82	82	82.06	92.5	92.5
Length of stroke	8.5	3.5	4	4	8.67	4	4
Number of revolutions, per minute	60.166	70.5	60.333	55	61.6	57.375	50
Weight per square inch on safety-valve	20	20	20	20	20	20	20
Nominal horse power	600	500	800	800	800	1000	1000
Indicated horse power	2452.2	2323.8	3781.5	3217.5	3350.3	4523.8	3616.6
PROPELLER.							
Description	...	...	...	Common, 3 blades.	...	...	...
Diameter	18	18.08	19	19.08	20	20	20
Pitch	26	20.42	27.5	27.83	25	28	32.5
Length	3.57	3.16	4.16	3.5	3.5	4.5	4.5
Immersion of centre at trial	8.67	8.01	8.08	8.92	10.57	9.25	10.25
Number of revolutions	60.166	70.5	60.333	55	61.6	57.375	50
Speed of ship, in knots	13.287	18.067	13.022	13.289	13.087	13.565	13.001
Speed	15.431	14.198	16.366	15.000	15.191	15.847	16.029
Slip, in knots	2.144	1.131	3.344	1.811	2.104	2.282	3.028
Slip, per cent.	13.90	7.97	20.43	11.99	13.85	14.40	18.89
Speed ¹ × ① ÷ indicated horse power	555.5	508.9	479.3	589.4	515.8	523.6	534.7
Speed ² × ② ÷ indicated horse power	183.3	188.9	147.6	183.3	180.3	156.4	187.4
Wind	No. 3.	Calm.	No. 5.	Calm.	No. 2.	No. 3 to No. 4.	Light breeze.
Sea	...	...	...	...	...	Smooth.	Smooth.
Remarks	...	...	...	...	...	...	...

TABLE VIII.—MEN-OF-WAR OF WHICH THE QUANTITIES OF BOILERS ARE GIVEN.

	GROUP 5.		GROUP 2.		GROUP 3.			
	St. George.	Colossus.	Chesapeake.	Bullfinch.	Renown. Half-boller.	Lee.	Leven.	Algerine.
Length in feet	206.5	194.33	207	108	244.75	125	125	125
Breadth in feet	55.46	56.42	50	22	55.33	23	23	23
Mean draft of water, in feet	24.85	12.32	21.93	6.75	23.67	8.08	8.25	8.12
Area of immersed section, in square feet	1012.4	911	758	132	1050	150.5	154.5	151.5
Displacement, in tons	4559	3785	3402	266	5320	367	378	370
ENGINES.								
Description	Horizontal.	Hor. Trunk.	Horizontal.	H. P. doub. trunk.	H. doub. acting.	Hor. H. Pr.	Hor. H. P.	Hor. H. P.
Number of cylinders	2	2	2	2	2	2	2	2
Diameter of cylinders, in inches	71	58.25	64	22.92	89.5 & 36	18	18	18
Length of stroke, in feet	3	3.25	3	1	4	1.5	1.5	1.5
Number of revolutions, per minute	46	53	...	194	43.5	154	156	158
Speed of piston, in feet per minute	276	344.5	...	388	342	462	468	474
Nominal horse power	500	400	400	60	800	80	80	80
Indicated horse power	1123	1020	897	241.48	1429	303.6	299.5	292.9
Pressure of steam in boiler, in lb.	17	20	...	60	20	60	60	60
Pressure in cylinder, in lb.	16.5	18.7	...	36.02	12.83	42.6	41.5	40.2
Pressure from vacuum, in lb.	12	10.35	...	...	8.88	...	...	...
Total weight of engines, in tons	115	70	93	6.25	163	6.5	6.05	6.06
PROPELLER.								
Description	...	...	...	Griffiths.	...	...	...	...
Diameter	18	17.12	17	6	19	6.5	6.5	6.5
Pitch	20	18.46	22.5	5.57	28	7.67	7.67	7.67
Length in line of shaft	8	2.89	3	1.06	3.5	...	...	...
Number of blades	2	2	2	2	2	2	2	2
Depth of immersion from top of blade to surface of water	5.46	5.22	2.79	0.08	1.83	0.61	1.20	0.87
Boes, in feet	3.75 × 1.83	3.26 × 2	3 × 1.75	1.67 × 1.75	3.5 × 2	1.16 × 0.75	1.16 × 0.75	1.16 × 0.75
Weight of screw, in tons	6.6	6.95	6.55	0.30	10.75	0.612	0.612	0.612
Speed of ship, in knots per hour	4.5	6	7.2	8.524	9.145	9.270	9.270	9.30
Number of revolutions of propeller, per hour	...	...	...	194	43.5	154	156	158
BOILERS.								
Description	Tubular.	Tubular.	Tubular.	Cyl. tubular.	Com. tubular.	Cyl. tubular.	Cyl. tubular.	Cyl. tubular.
Length, in feet	15.5	12.08	13.08	13.67	13.67	16.25	16.25	16.25
Breadth, in feet	11.33	11.75	11.5	4.33	11.25	4.67	4.67	4.67
Height, in feet	11.08	11.67	11.5	...	13	...	...	...
Steam-room, in cubic feet	1996	1288	1568	127	2562	131	131	131
Water-room, in cubic feet	2170	1690	2100	360.5	3780	446	446	446
Number of furnaces	20	12	16	3	24	3	3	3
Grate surface, in square feet	337.5	253	277	33.75	544	33	33	33
Total heating surface, in square feet	9449.5	6644	7387	1096.25	14,854	1517	1517	1517
Number of boilers	4	4	4	3	6	3	3	3
Weight of boilers, total, in tons	128	90	112	13.5	179.8	14.25	14.25	14.25
Weight of water in boilers, in tons	...	...	...	10.3	108	12.75	12.75	12.75

TABLE VIII. (continued).

	GROUP 3.		GROUP 4.					GROUP 6.	
	Slaney.	Marlborough.	Flying Fish.	Renown.	Diadem.	Doris.	Orlando.	Mersey.	
Length in feet	125	245.5	200	244.75	240	240	300	300	
Breadth in feet	23	61.20	30.33	55.33	48	48	52	52	
Mean draft of water, in feet	8.08	26.24	11.42	23.67	20.67	20.49	21.79	21.57	
Area of immersed section, in square feet	150.5	1169	226	1050	768	732	876	865	
Displacement, in tons	367	6035	1033	5320	3918	3716	5456	5308	
ENGINES.									
Description	Hor. H. P.	Horizontal.	Horizontal.	H. doub. acting.	Horizontal.	H. doub. acting.	H. doub. acting.	H. doub. acting.	
Number of cylinders	2	2	2	2	2	2	2	2	
Diameter of cylinders, in inches	18	82	58.5	89.5 & 36	82	89.5 & 36	100 & 38	92	
Length of stroke, in feet	1.5	4	2.25	4	4	4	4	4	
Number of revolutions, per minute	155	54.66	79	54.5	55.25	53.71	53	55.25	
Speed of piston in feet per minute	465	437.33	355.4	436	442	429.68	424	442	
Nominal horse power	80	800	350	800	800	800	1000	1000	
Indicated horse power	299.8	3054.26	1049.68	2754.64	2685.04	3009.03	3992	4044	
Pressure of steam in boiler, in lb.	60	20	19.5	20	18.5	20.6	19.67	20	
Pressure in cylinder, in lb.	41.8	21.82	18.44	19.74	18.98	21.88	22	22.71	
Pressure from vacuum, in lb.	..	9.7	6.86	9.9	9.39	10	9.87	10.09	
Total weight of engines, in tons	6.05	160	49	163	160	162	194	200	
PROPELLER.									
Description	..	Maudsley.	Common.	..	Griffiths.	Griffiths.	..	..	
Diameter	6.5	19	13.16	19	18	20.08	20	20	
Pitch	7.67	27.25	19.96	28	18.08	30	29.75	29.42	
Length in line of shaft	..	3.61	3.01	3.5	..	4.20	4.5	4.25	
Number of blades	2	2	2	2	2	2	2	2	
Depth of immersion from top of blade to surface of water	1.04	4.75	0.08	1.83	1.35	0.29	..	0.16	
Boss, in feet	1.16 x 0.75	3.83 x 2	3 x 1.5	3.5 x 2	3.75 x 5	3.67 x 5	3.83 x 2.25	..	
Weight of screw in tons	0.612	12	3.85	10.75	10.20	11.38	12	13	
Speed of ship, in knots, per hour	9.350	11.217	11.536	11.43	11.899	12.158	13.16	13.290	
Number of revolutions of propeller, per hour	155	54.66	79	54.5	55.25	53.71	53	55.25	
BOILERS.									
Description	Cyl. tubular.	Com. tubular.	High and low tub.	Com. tubular.	Com. tubular.	Com. tubular.	Com. tubular.	Com. tubular.	
Length, in feet	16.25	13.92	10.25	13.67	13.83	13.65	14.42	14.57	
Breadth, in feet	4.67	11.75	10	11.25	11.61	11.25	12.25	11.5	
Height, in feet	..	13.33	11	13	12.67	11.75	11.83	12.08	
Steam-room, in cubic feet	131	2700.8	1528	3562	2454.4	2263	3316	263.7	
Water-room, in cubic feet	446	3920	1365	3780	3920	4620	5740	136	
Number of furnaces	3	24	18	24	24	24	32	32	
Grate surface, in square feet	38	544	247	544	544	544	688	720	
Total heating surface, in square feet	1517	15,166.8	7005	14,854	15,166.8	14,749	19,431	18,881	
Number of boilers	3	6	6	6	6	6	8	8	
Weight of boilers, total, in tons	14.25	211.8	76.6	179.8	192.25	172	228	263.7	
Weight of water in boilers, in tons	12.75	112	39	108	112	132	164	136	

ON CERTAIN NEW PROCESSES IN PHOTOGRAPHY.*

By J. SPILLER, F.C.S.

I HAVE the pleasure of submitting to the notice of the section several interesting results and improvements in photography, based, it may be said, on the chemistry of gelatine. The processes to which I refer are the various modifications of the Woodbury type, including the new method of micro-photo-sculpture, the art of photo-lithography, as practised in the Royal Arsenal at Woolwich, and some illustrations of the use of gelatine or albumen, on a foundation of silk, satin, or cambric, the work of Mr. H. B. Pritchard, of the War Department. The Hon. H. Fox Talbot was one of the first to describe and make a practical use of the action of light upon a mixture of gelatine and a soluble bichromate, and after him Colonel Sir Henry James, Mr. Swan, of Newcastle, and Mr. Woodbury, of Manchester, have applied the same chemical principle in new directions. It is known that the chemical rays of light have the effect of rendering insoluble gelatine to which a bichromate has been added. It would appear that this oxidising salt hardens the animal substance, by forming with it a combination of chromic oxide. In proof of this view, it may be stated that Mr. Swan has lately devised a mode of working, in which a minute quantity of chrome alum or sulphate of chromium is used instead of the red chromate, and it is found that when dried this mixture is not again affected by water. The carbon prints of Mr. Swan, which were exhibited and so much admired last year at Nottingham, are illustrations of the use of a chromate in conjunction with gelatine and pigments. Mr. Woodbury's process is also based on the insolubility of the chromo-gelatine after exposure to light, and upon the subsequent action of water upon a sensitive film, which has been in different degrees influenced by insolation under an ordinary photographic negative. The depths of tint in the original are represented by variations in the thickness of the film of gelatine left unacted upon by water, and thus dried may then be used as a matrix to produce corresponding series of depressions upon a surface of lead or type metal by the aid of a powerful hydraulic press. The blocks so produced serve for printing off a great number of proofs when they are liberally "inked" with warm gelatine, highly charged with Frankfort black or other suitable pigment, and pressed down upon a smooth sheet of paper until the excess of ink is forced out on all four sides of the block and so removed from the space constituting the area of the picture, which, when set, is, lastly, protected with a varnish of collodion. (Specimens of the Woodbury type were exhibited.) A glass plate may be used instead of paper to receive the ink, and this, backed with another (opal) glass, gives an excellent result, suitable for a variety of ornamental purposes. (Specimen shown.) Mr. Woodbury has lately perfected a modification of his process, which is applicable to the representation in high relief of microscopic objects. The method consists in spreading a warm solution of gelatine, containing a little sugar and bromate of potash, over a glass plate previously coated with collodion. The film sets on

cooling, and is then placed in contact with an ordinary photographic negative of the microscopic objects to be delineated, exposed to light, submitted as before to the action of water, and the soluble portions washed away. When the surface moisture has evaporated, a mixture of plaster of paris, containing a small proportion of alum, is poured over the relief to the thickness of half-an-inch, and left to set. When dry it will be found, owing to the alum in the plaster hardening the surface of the gelatine directly on coming in contact therewith, to leave the gelatine easily, without any fear of adhesion. To give a finished appearance to the resulting casts, this intaglio, when dry, may be placed in a lathe, and a suitable border twined on it, which will be represented in the resulting proofs by a raised border, similar to what is seen on medallions or plaster casts. The name of the object may also be neatly engraved on the intaglio, to appear in raised characters on the reliefs. This intaglio should then be well waxed to fill up the pores, and is ready for taking any number of impressions in plaster; or a better plan is to take one in plaster, and, having smoothed away any defects, to mould a reverse in sulphur, which will give a greater number of fine impressions. (Specimens exhibited.) Great progress has been made during the last year in perfecting the details of photo-lithography, and the results which I now exhibit are illustrations of the practical use of this art as a means of procuring on a reduced scale printed reproductions of the large series of lithographs issued for the use of the British army by the Royal Carriage Department. Negatives of the required size are taken in the first instance by the collodion process, this service being performed in the photographic establishment of the War Department at Woolwich under my supervision. The pictures are then copied upon a sensitive surface, prepared by floating a sheet of bank post paper upon warm chromo-gelatine solution, made as follows:

I. Gelatine, 3 oz.; hot water, 40 oz.

II. Bichromate of potash, 2 oz.; hot water, 10 oz.

The two solutions are mixed together, and should then be kept from the light. The prepared side of the paper is, when dry, laid against the negative, and for a short time is exposed to light. It is then greased all over by spreading a thin layer of "litho-retransfer ink" upon stone, and passing it through a lithographic press, and the whole surface is in the next place submitted to the action of warm water thickened with gum. The ink resting upon the unexposed portions of the print is thus removed, the gelatine in these parts still remaining perfectly soluble, and the paper is washed with dilute gum water, using a sponge to assist in detaching the loosened layer of ink, and finally washed with warm water alone. This sheet of paper is an accurate transcript in lithographic ink of the original photograph. All the lines should be clear and sharp, and there will be no difficulty in transferring to stone and printing off any required number of impressions by following the details of the ordinary lithographic process. The cost of production is very trifling, and a large number of prints, both plain and coloured, have been executed in this manner by Mr. Henry Butter, of the Royal Carriage Department. I have, lastly, to show a few specimens of photograph printing upon silk, satin, and cambric, the work of Mr. H. B. Pritchard, of the

War Department. He produces them by salting the fabrics with the following solution: Common salt, 5 grammes; water, 500 cubic centimetres; albumen, the whites of four eggs. The air-dried fabric is then sensitised, printed, and fixed, in the ordinary manner, but with as little delay as possible. This method furnishes a means of reproducing photographs upon a stronger and more flexible basis than paper, and is particularly applicable to diagram purposes, architectural plans, and we have used it in the Royal Arsenal for preparing sketches and illustrated descriptions for military instruction and use in the field.

INDICATED HORSE POWER.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Moorsom's solution of the problem of finding out the speed of piston is exceedingly clear and satisfactory, and I am much obliged for the trouble which he has taken; there is, however, yet wanted some plan of integrating the speeds at the different points of the stroke in connexion with the pressures at those points, and I trust that Mr. Moorsom will be good enough to do this also. At the present time, interests of the greatest importance connected especially with steamships are dependent on the right understanding of the difference between real and nominal horse power; and I think I have shown that the power developed in the cylinder when the engine is working expansively is less by from 6 to 10 per cent. than is given by the usual method of calculating indicator cards. It is probably of less importance to ascertain the inaccuracy exactly than just to keep in mind the fact. If you calculate the power by multiplying the average pressure shown on one card by the *average speed of piston*, only two shapes of card will give a strictly accurate result, viz., a perfect triangle and a perfect rectangle, or a figure which is based on these forms in a symmetrical way. In all cards with *concave* lines, as in expansion cards, the result attained by the usual method of calculating indicated horse power will be too high, whereas cards with *convex* lines (say a card where steam is cut off at three-fourths) will give too low a result.

Your obedient Servant,

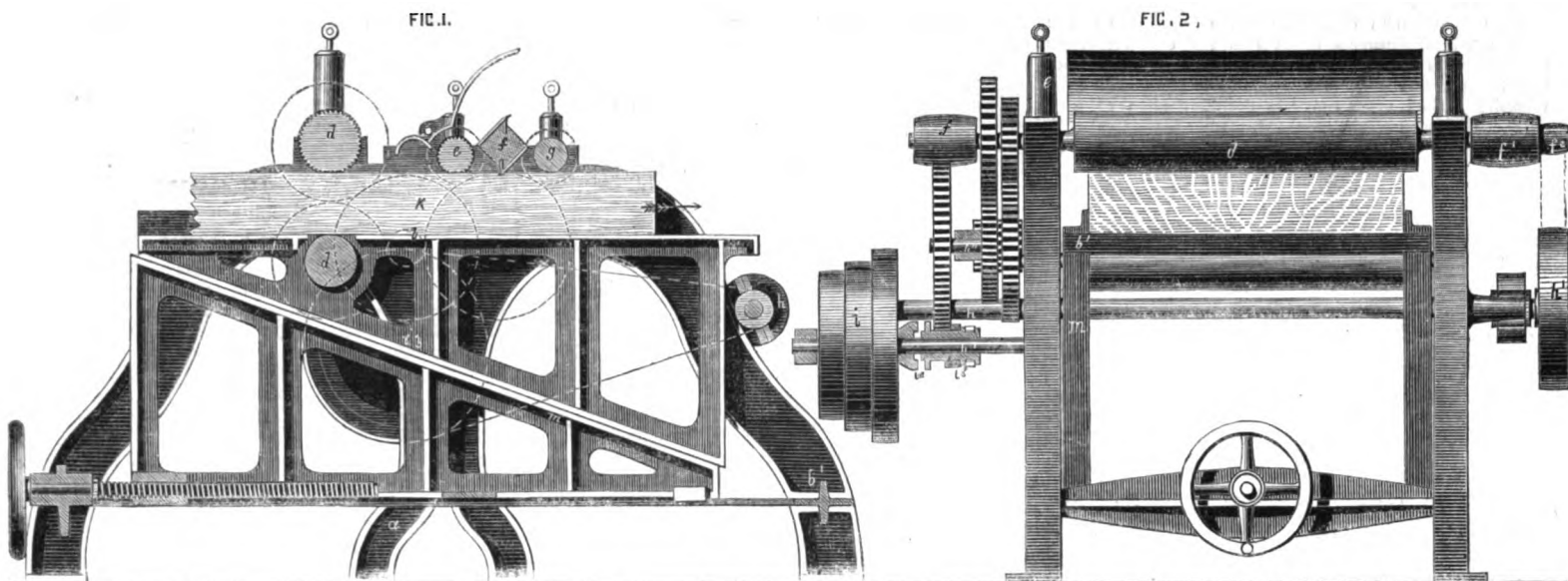
Newcastle, September 13, 1867.

J. W. R.

RAILWAY STATISTICS.—The statistics of the railways in the United Kingdom show how large is the capital now invested in that description of property, and the consequent extent of personal interest in the financial condition of railway companies. At the end of 1865 the total of the capital paid up in shares and loans was returned as 455 millions, an increase of nearly 200 millions upon the capital since 1852. The capital in 1865, for lines in England and Wales, amounted to 380 millions; for lines in Scotland 50 millions, and for lines in Ireland 25½ millions. The length of lines opened in the United Kingdom at the end of 1865 was 13,289 miles, an increase of 6000 miles upon the length of lines in 1852. In 1865 there were 9251 miles of railway in England and Wales, 2200 in Scotland, and 1338 miles in Ireland. These figures refer to both double and single lines, but the proportion of single lines was about one-third of the total length in England and Wales, rather more than one-half in Scotland, and nearly three-fourths in Ireland. The total of the traffic receipts in the United Kingdom has increased from 15½ millions in 1852 to 35½ millions in 1865; of the latter amount 18½ millions were net receipts. It is satisfactory when so much distrust of railway investments prevails, to find that in 1865 the net receipts show an average interest of a little over 4 per cent upon the aggregate paid-up capital for lines in England, nearly 4½ per cent. for lines in Scotland, and 3½ per cent. for lines in Ireland.

* Paper read before the British Association at Dundee.

WHITNEY'S WOOD-WORKING MACHINERY AT THE PARIS EXHIBITION



We have in a previous article noticed the originality of design and the excellence of workmanship which characterise the wood-working machines of Mr. Whitney, in the American department of the Paris Exhibition, and a few weeks ago we described and illustrated Mr. Whitney's machine for turning small ornamental pillars, whilst we now represent on the present page and page 284 the three other machines exhibited by this maker, all equally well worthy of notice. Figs. 1 and 2 represent Mr. Whitney's machine for planing wood. This tool is designed for planing one surface of the wood only, by means of a revolving cutter, shown in section at *f*, Fig. 1. This cutter is provided with two continuous straight blades as knives, one set against a counter blade, like the finishing cutter of a joiner's plane. The spindle carrying the cutter is held on bearings fixed to the framework of the machine itself, and does not allow of any movement in a vertical direction, like the spindle of most other wood-planing machines. The difference of thickness to be planed is, in this machine, allowed for by a provision for raising and lowering the table or bed upon which the timber is placed. This bed, *l*, is, as shown in Fig. 1, placed upon an inclined plane, *m*, of which it forms the counterpart, and upon which it slides longitudinally, when moved by means of the screw, *m'*, and nut, *m''*. The movement of the table, *l*, forward and backward upon the inclined plane, *m*, causes the horizontal plane, which forms the top of the table, to rise or fall in a corresponding proportion, and the whole is geared so that one revolution of the hand wheel and screw, *m'*, will raise or lower the top of the table vertically $\frac{1}{2}$ in. Mr. Whitney prefers the adjustment of the table to that of the spindle, as adopted by most other machine makers, because he is thereby enabled to secure the bearings of his cutter-spindle more firmly to the framework of the machine, and thus avoids the principal source of vibration in the action of his machine.

Mr. Whitney is careful to arrange all his gearing so as to obtain no vertical strain upon his rolls from the gearing in either direction; there is, of course, equal danger in a tendency of the gearing to lift the rollers, as, in a pressure downwards upon the work, as in either case the inequalities of grain or structure in the wood produce an irregular effect upon the rolls, and the result is the production of a more or less undulating or uneven surface. Another important point about Mr. Whitney's planing machine is the manner in which the feed rollers are geared, for the purpose of effectively avoiding any accumulation of pitch and other gummy substances upon the surface of the feed rollers. The wood and shavings, after being fresh cut by the revolving planer, have the tendency to cause a quantity of such gummy substances to adhere to the surface of the rollers, and to accumulate upon the latter so as to cause indentations in the planed surface, in consequence of the irregular and vibrating movement of the whole, and the irregularity of the roller surface itself. Mr. Whitney avoids this effect by giving to the surfaces of the feed rollers in front of the revolving planes, and to those behind the latter, a slightly different speed of motion, so as to effect a constant slipping of the back rolls upon the surface of the wood. This stopping or rubbing action very effectively prevents any irregular accumulation of adhesive matter, and very completely prevents the consequences observed to take place without this precaution. Mr. Whitney patented this mode of gearing the feed rolls of a wood-planing machine a few months ago.

Figs. 3, 4, and 5 (page 854) represent a novel machine constructed by Mr. Whitney as a supplement to his planing machine, for fine and highly finished work. It is a scraper, for clearing off from the planed surface of the wood the last and finest irregularities and roughness left by the cutting edges of the planing machine. This effect is produced by the action of a scraper blade, shown in detail in Figs. 9 and 10. The edge of the scraper, *r*, is got up simply by raising a burr upon the blade by means of a burnisher, and the whole is set so as to allow only this burr to project over the surface of the guide iron, *r'*, and of the back stay, *r''*. The wood is traversed across the scraper by means of two pairs of feed rollers, *9, 9'*, *9'', 9'''*, Figs. 3 and 4. The feed rollers are adjustable vertically, by means of four screw spindles, *u', u'', u''', u''''*, all geared together and worked from one hand wheel, *u*. The thickness of the material being in this manner provided for, it is still necessary to allow for any slight variations and irregularities. This is done by giving to the scraper itself the possibility of yielding and adjusting its position within a limited degree. The scraper is mounted upon a support, *v*,

Fig. 9, and this again is fixed upon a lever, *v'*, Fig. 4, which bears against an adjustable spring, *v''*. The support, *v*, allows the scraper to place itself in any slightly inclined position that may be required to accommodate the irregularities of the board in any given section, and the lever and spring, *v', v''*, allow of the scraper being raised or lowered, according to the requirements of the different successive sections of the board passing through this machine. The work produced by this tool is remarkably smooth and good, and surpasses in its appearance all that we have been as yet accustomed to see produced by wood-planing machinery.

Figs. 6, 7, and 8 represent Mr. Whitney's circular-saw bench. This machine carries two different circular saws, *f* and *g*, mounted on a double armed bearing, *h*, which is turned round a fixed spindle, *j*, by means of a worm and worm wheel, *l, m*, worked from a handle at the side of the machine framing, *a*. The rotating movement of the fixed spindle, *j*, causes either of the circular saws to rise or fall in the narrow slot of the table through which the saw projects, and a still further movement will cause the saw at the top to disappear entirely, and to change places with the other saw, which will then come up through the slot, and allows of beings set to any required height in the same manner as the other saw. Both saws rotate in the same direction, and they are driven from a belt, *n*, having its driving pulley below the table; but only that one of the two pulleys and saw spindles which stands above is in contact with the belt at one time, so that only one of the saws is in rotation while working, and the other below the table is at rest until it is brought up in its turn when wanted. The object of fitting up two saws is to provide for the different requirements of the wood, when cut parallel with the grain or across the latter. The two saws, accordingly, have teeth of different size and shape, one being adapted for parallel and the other for cross grain. The feed motion for the wood in a straight line is obtained through that part of the table which carries it. This table is mounted upon a slide, *b' b''*, and can be traversed horizontally in a straight line. A set of adjustable gauges and guides make this machine very complete and useful for a variety of work, all of which it finishes with great nicety and accuracy. There is a circular gauge for cutting the work to any required angle across its end, as shown in plan at *p, p'*. Another guide for gauging the width of long, parallel, or taper pieces is shown in plan at *q, q'*, and this is adjustable also vertically, as shown in Fig. 8, at *r, r'*, so as to cut a bevelled side of a parallel piece. Furnished with all these adjustable guides and templates, and finished with nicety and accuracy, as this machine is, it allows of the production of unusually neat and delicate work, and recommends itself as a model for very general imitation in England and on the European continent. We have once before observed that European makers of wood-working machinery are indebted to Mr. Whitney for a useful lesson on this present occasion, and we believe that our readers, on inspecting the drawings of the tools just described, and of that represented in our previous number, will agree with us in this opinion.

MEAT TRANSPORT IN THE UNITED STATES.—A company, which proposes to transport to the New York market fresh meat from the Western States, has just submitted for public examination a model of the wagons which it intends to employ in order to attain this object. The points of the Western States nearest to New York are at a distance of 300 to 375 miles from that city; and the company will collect meat for conveyance over distances of 600 and even 750 miles. One of the wagons shown had brought meat from Newark, in Ohio, a distance of 750 miles. The meat had been four days *en route* during warm weather; but when it arrived it was in excellent condition. The wagons are lined with a thickness of 3 in. of cork intended to absorb humidity, and prevent contact with the atmosphere. This is placed between an outer chest and an inner chest, and with the help of ice and a continued current of fresh air, the desired object is said to be effectually obtained. The wagon exhibited was capable of receiving the flesh of six beasts and 122 sheep.

THE BOMBAY AND BARODA RAILWAY.—About 120 ft. of the embankment of the southern extremity of the bridge over the Nerbudda river on the Bombay and Baroda Railway has been washed away by a flood. The country south of the Nerbudda is flooded for miles. The line of telegraph has been washed away for a distance of four miles.

ON IRON AND STEEL IN THE PARIS EXHIBITION.*

By Mr. FERDINAND KOHN.

IN the discussion which followed Mr. Fernie's interesting paper on "Iron and Steel in the Paris Exhibition," the president of this section did me the honour to address to me a question about the processes now followed in this country and abroad in manufacturing steel castings and castings of malleable iron. Considering the importance of this subject, and the great variety of such processes now in existence and in practice, I did not, at that moment, think myself sufficiently prepared to address this section, but I proposed to draw up a few notes on that subject and upon some others closely connected with it. Having done so in the short space of time afforded me, and almost entirely from memory, I do not venture to bring this communication forward in the form of a complete paper, but I present it as an addition to the valuable paper read by Mr. Fernie a few days ago.

The collection of iron and steel at the Paris Exhibition is one of the most complete and instructive representations of the present state of iron metallurgy in all its branches which could have been brought together at any one spot under any circumstances. The rapid progress which the science and practice of iron and steel manufacture have made during the last few years, and the state of transition into which the whole iron industry of the world has been placed in consequence of these great and sweeping innovations, are the natural causes which made the display of iron and steel on this occasion more than usually desirable to exhibitors and attractive to the professional visitors.

I commence with the main cause of the great industrial revolution which we now witness, an invention with which the British Association has a historical connexion, viz., the Bessemer process. The importance and extent which the Bessemer process has acquired during the eleven years of its existence I cannot better illustrate than by quoting an approximate estimate of the present rate of production of Bessemer steel and of the productive power of the existing Bessemer steel plant in the different countries. My quotation is from a report made to the Austrian Government by Professor Tunner, one of the greatest authorities on metallurgy on the Continent, and one of the jurors in the iron and steel department at the Paris Exhibition. According to Professor Tunner's estimate, there are now in England fifty-two converters in operation, capable of producing, collectively, 6000 tons of steel per week. Russia has 24 converters, with a capability of make equal to 1460 tons; France, with 12 converters in operation, can produce 880 tons; in Austria, 14 vessels can turn out 650 tons; and Sweden, with 15 vessels, has a productive capability of 530 tons per week. There are two converters at Seraing, in Belgium, and two more in Italy, also one or two in Russia, making the total power of production now available for Bessemer steel making in Europe equal to about 475,000 tons per annum. To this we must add America, with at least 50,000 tons, giving a total exceeding half a million tons of steel. The actual production of this present year does not of course come up to this figure; but it is, in all probability, considerably above 200,000 tons. In this estimate we find England's power of production fully twice as great as that of the rest of the world put together, and its actual manufacture of steel follows very nearly the same proportion. English Bessemer steel is not very well represented at Paris, but that purely accidental circumstance cannot mislead the judgment of anybody who is at all acquainted with the standing of this article in the markets of the world, with the quality of steel now turned out by the Bessemer steel works of this country, and with the extent of the trade done

* Paper read before the British Association at Dundee.

by them. The finest specimens of Bessemer steel exhibited at Paris are those made at Neuberg Works, in Austria, and at Fagersta, in Sweden. In both these works the raw materials consist of the purest ores known in Europe. The ores are smelted with charcoal, and the liquid iron is run from the blast furnaces direct into the converters; no spiegeleisen is required, but simply a small quantity of liquid iron from the same furnaces is used for adding the requisite carbon after complete decarburisation of each charge. In these localities, the Bessemer process exists in that ideal form in which it was first imagined by its inventor, but which Mr. Bessemer himself has been obliged to modify in order to make it suit the inferior qualities of ore existing in this country. That he has been eminently successful in this respect may be inferred from the fact that English hematite iron is exported in large quantities to the Continent, and used by steel-makers in France and in Germany in preference to the iron made in their own respective localities. I must confine myself to these general remarks upon the Bessemer steel in the Paris Exhibition, but I have given numerous and detailed accounts of the principal exhibits in the columns of *ENGINEERING*, vols. iii, and iv.

I now come to those much-admired steel castings of Rhenish Prussia which raise so much interest and curiosity, both by their extraordinary sizes and qualities, and by the secrecy and mystification which surrounds their manufacture. Prussia is a country practically without any patent laws. Inventors therefore are at war with society there, and that war manifests itself by the closed doors of all great industrial establishments, and by an amount of jealousy with regard to technical information which is entirely unknown in any other place. This explains the position of those celebrated steel-makers, like F. Krupp, the Bochum Company, and some others, who have succeeded in making important improvements in steel manufacture, and are now obliged in self-defence to protect their mental property from piracy in this barbaric manner. I have already stated it as a suggestion that the steel castings of the Bochum Works may have been produced by running into the moulds a metal which contains more carbon than steel, and is, in fact, cast iron, and by subjecting the finished casting to a subsequent process of decarburisation. There are many other steel-makers who make use of a similar process for obtaining sound malleable castings of great strength. The process of making malleable cast iron long practised in England consisted in surrounding the cast iron with a quantity of pure iron ore, or oxide of iron, and exposing it to a high temperature for a length of time which was proportionate to the thickness of the mass of cast iron. By this process of cementation carbon was removed from the metal, and combined with the oxygen contained in the ore. This process is necessarily imperfect, since carbon is not the only impurity contained in cast iron, and the majority of the other elements is left in the mass. It has been therefore, found necessary to use exclusively charcoal iron made with cold blast for this process, since this material contains less impurities and a smaller percentage of silicon than coke iron.

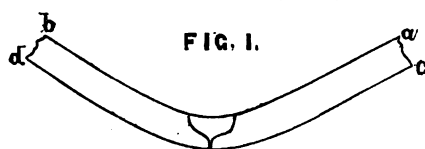
An improvement upon this process is that now practised by Messrs. McHaffie, Forsyth and Co., in Glasgow. This I understand to consist in melting hematite iron in a cupola with some addition, the composition of which is kept a secret. The iron, when cast, is very hard, white, and brittle, but after decarburisation it very much resembles cast steel in all its properties. According to this description of the process, I should suppose that the admixture in the cupola may principally consist of an oxide of manganese, which would deprive the iron of a part of its silicon, and thereby make it more suitable for being converted into steel by cementation. Still it remains doubtful whether any amount of admixtures will sufficiently purify the iron in the cupola for producing good steel by cementation, and the inferior tenacity of that material, to which Professor Rankine referred a few days ago, seems to be due to this cause. One of the most scientific methods of producing steel castings is that invented by M. Pierre Martin, of Sireuil, in France. M. Martin melts pig iron of a good quality, such as is used in the Bessemer process, in a Siemens furnace. He works at a very high temperature, and, by the action of a slightly oxidising flame upon the surface of the iron, succeeds in removing the silicon and other impurities from the iron, leaving only an excess of carbon in the liquid mass. This is then tapped from the furnace and cast. The castings, after being sufficiently cooled, are placed in another Siemens furnace, having a lower temperature and a flame slightly overcharged with gas. This flame effects the process of cementation in a very perfect and uniform manner, the carbon of the iron being taken up by a part of the carbonic acid contained in the flame. As the process continues, the temperature of the furnace is raised, the flame being always maintained in its neutral character to prevent oxidation of the surface of the metal by the action of free oxygen. After a certain time, which depends on the thickness of the article operated upon, the process of cementation is completed, and the casting converted into steel. M. Martin has exhibited some very fine castings of that kind at Paris, and his process attracts a great deal of attention on the part of steel-makers. Messrs. Emile and Pierre Martin have also introduced another new steel process, which is now making rapid progress in France under the name of the Martin process. This consists in melting pig iron in the Siemens furnace, as described before, and in adding to the molten mass a suitable proportion of wrought iron, steel or pure iron ore, a process patented and described long before

this by several inventors, but never as yet practically and successfully carried out. The Martin process, as far as is known at present, is a practical success. It has been recently introduced in several of the largest establishments in France—the Creusot works amongst these—and it is working to satisfaction everywhere. The principal advantage of this process consists in the facility which it affords for using up old iron and converting it into steel.

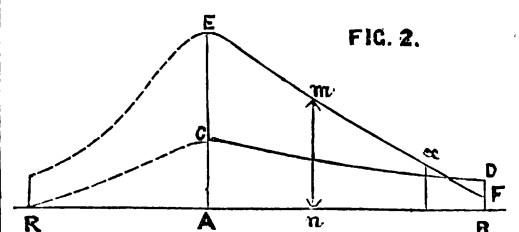
I have only to mention one more new process for making steel represented in Paris. This is a recent invention made by Mr. Siemens, and consists in making steel direct from the ore in a regenerative gas furnace. Mr. Siemens has exhibited a model of his proposed furnace, and a small piece of steel made by his new process, showing that his experiments have been so far successful.

In concluding these notes I wish to make a few remarks upon that vague notion now existing in this country, that the superiority and predominance of British iron manufacture had ceased to exist, or was threatened to be overthrown in the future by Continental competition. There are certainly no indications of such a state of things in the Paris Exhibition. If we look at the elements upon which all iron industry is based, we find British coal, although rising in price, still cheaper and better than that of most other countries, we find British hematite and other ores of similar purity abundant in this country, in close proximity to the great coal districts, while the French are importing iron ores from Elba, Sardinia, and even from Africa, and the Swedes and Austrians, who have good ores, are restricted to use charcoal as their fuel. With regard to the better qualities of iron, this country has, therefore, an advantage over all other iron manufacturing localities in the first cost of materials, which cannot fail to secure its superiority for some time to come. Equally so are the districts which produce the cheapest kinds of iron capable of holding their position in the markets of the world against anything that has been produced on the Continent, or shown in this Exhibition. From the finest Styrian Bessemer steel down to the cheapest rolled iron made in the Saar district of Prussia, or in Belgian ironworks, there is nothing which can compete with British iron in the long run. Krupp's steel is the only article, perhaps, that makes an exception; but this has been so for a long time past, and it is, therefore, no more likely now to interfere with the general superiority of British iron manufactures than it did many years ago.

Having yesterday heard the very valuable and interesting report presented to this section by Dr. Fairbairn, I desire to add a few remarks with regard to some tests of iron and steel which I have noticed in the Paris Exhibition. There are many fractured steel bars of varying degrees of hardness exhibited by different parties, and in all these a striking resemblance presents itself with regard to the appearance of the lines of rupture. The fibres in tension break in a straight line, while in that portion of the bar where the fibres are compressed, a wedge-shaped piece (Fig. 1) is forced out.



The shape of this wedge, and the relative position of the point where its two sides meet, and which point seems to represent the neutral fibre of the bar, appears in all specimens to be strictly dependent upon the degree of hardness of the steel. The tests in which this is most prominently shown are those made by Mr. David Kirkaldy for the Fagersta Works, in Sweden; and these are all the more instructive, since the exact chemical analysis—so far as contents of carbon are concerned—is given with each specimen. It is clearly visible that the point representing the neutral fibre lies nearer to the line, *a b* (or top flange), in the harder specimens, and it descends towards the line, *c d* (or bottom flange), in the specimens of a softer kind, until at last, in the softest specimens, the wedge disappears altogether, since they double up without fracture. This seems to indicate a varying proportion of tensile and compressive strength in steel of different degrees of hardness, which will be best illustrated by a kind of diagram (see Fig. 2). Suppose the datum



line, *A B*, to be graduated in the divisions corresponding to decreasing percentage of carbon in the steel, and the line, *A C*, to be proportionate to the tensile strength of the hardest steel, then the decrease in tensile strength with decreasing contents of carbon will be represented by a curve, *C D*, the law of which has, of course, not been ascertained as yet. If, further, *A E* represents the strength of the same hardest specimen of steel in compression, it seems from what has been observed hitherto, and also to some extent from Dr. Fairbairn's tables, that the line, *E F*, which represents the

decrease of strength in compression in softer steel, will fall more rapidly than the first, and ultimately cross *C D*, so that for wrought iron, which must be supposed to be the last element of this series, the resistance to compression will be only half that which is offered to a tensile strain. The softest kinds of steel now in use seem to range somewhere about the point where the two lines cross each other, while in the hardest kinds it appears that the strength in compression may be about three times as great at that in tension. I think, therefore, that it would not be advisable for engineers to rely in all cases upon the average proportion arrived at by Dr. Fairbairn, and which is expressed in his abstract of results, viz., that the strength of steel in compression is about double its tensile strength. This proportion seems to be correct only for those kinds of steel which on the diagram represented the medium quality of the specimens tested, and might be represented by the line *m n*. With regard to some of the softest specimens of steel, which, according to Dr. Fairbairn's tables, have given the highest results, I wish to draw attention to the fact that these specimens come from two different makers, viz., Messrs. Cammell and Company, and Messrs. H. Bessemer and Company. These specimens appear to be Bessemer steel of that quality usually made for boiler plates. I can find no better proof of the scientific perfection and reliability of the Bessemer process as practised in England than the close correspondence of the results obtained with these samples. There are two different establishments having no connexion with each other, entirely independent in their practical management; they both make a certain quality of steel to be used for boiler plates, and the results shown by their products under the test are so nearly alike, both in tensile and in compressive strength, as to fall almost within the limits of observation.

The President said he quite concurred with the author of the paper in his remarks on the patent laws. He instanced the reaping machine invented by Mr. Bell, which, he said, was, in consequence of no patent having been taken out for it, allowed to lie over a long time. Had Mr. Bell taken out a patent, some of the agricultural implement manufacturers would have taken to the invention, and the country would have had the benefit of its excellent qualities twenty or thirty years sooner. With regard to the diagram illustrating the relative proportions of tensile and compressive strength of different kinds of steel, he thought the curves, if continued on the other side, so as to represent iron with a greater percentage of carbon, would follow a course as indicated by the dotted lines, *C M* and *E N*, and the line *R N* would then represent grey cast iron, the tensile strength of which is below that of wrought iron. The strength in compression would fall less rapidly, as indicated by the curve, *E N*. This would then complete the diagram for the entire range now in existence between cast iron on one side and wrought iron, in which the percentage of carbon comes down to zero on the other side. He concluded by stating that the idea of constructing such curves was very useful, and that in future such curves should be constructed from the data already in existence in the Reports and tables.

THE PRESENT STATE OF THE MANUFACTURE OF IRON IN BRITAIN.*

By Mr. I. LOWTHIAN BELL.

(Continued from page 268.)

It is a mere repetition of a truth admitted on all sides, that the modern blast furnaces, forges, and mills abroad are in principle and in most details identical with those of this country, of such excellent construction as to have placed their owners on a level with ourselves so far as perfection of machinery is concerned. It is, however, not to be expected that those conditions which prevail here should find an exact counterpart abroad; and wherever a deviation from things as they exist with ourselves occurred, the foreign ironmaster was found, of course, adopting his mode of procedure so as to suit the change of circumstances. The chief difference between other countries and this is in the important matter of fuel. Here regular lying beds of coal, generally of great purity, and in very accessible positions, have furnished us with abundant supplies of this element for the production of iron, and upon terms more favourable than those within reach of the Continental ironmaker, who very frequently has to work with a combustible costly in itself, and containing a considerable amount of impurity. Long before it was thought of here, because the same necessity did not exist, our neighbours occupied themselves with devising ingenious methods of washing out the dirt contained in their coal, and afterwards in constructing ovens so as to coke the purified product with the least possible waste. They also conceived, and now practise on a very large scale, the idea of securing the advantages of large coal by cementing together in very well contrived machinery the improved small coal thus placed at their disposal. To meet the increased demand for pitch, which constitutes the cement used in this last-mentioned process, coke ovens are now in use abroad for condensing all the products of distillation, both of a tarry as well as those of an ammoniacal nature. In like manner the excess of heat, which passes away from the puddling and balling furnace, instead of being permitted to escape, was made available in France for raising the steam for driving the forge and rolling-mill machinery; but perhaps the most elegant and interesting application of a waste

* Paper read before the British Association at Dundee.

product was that effected by employing the gases which formerly flamed at the tops of their blast-furnaces for a variety of purposes for which hitherto solid fuel had been used. Now, it may be asked, were our own ironmasters indifferent spectators to those valuable ameliorations contributed by other nations to an art in which Britain might be supposed to occupy the first rank? The answer is, that no sooner did a change in the price of our fuel enable them to adopt, with profit, the purification of coal and the improvements in its conversion into coke than both processes were imported into this kingdom; and at the present day there is scarcely an ironwork in it of any consideration where the machinery is not driven by the waste heat from its own furnaces in the manner suggested by the example of our neighbours. As regards the use of the blast-furnace gases, not only have our furnace-owners availed themselves of the lesson taught them by foreign industry, but the mode of collection has been so improved as to afford, in many cases, results better than those obtained by the original inventors. At this time not less than 500,000 tons of coal are annually saved in the Cleveland iron district alone, by the state of perfection to which this admirable discovery has been carried. For many years past such are the advantages possessed by this country for the economical working of metals that, although the raw material for the finer kinds of steel had to be imported from other nations, we have been able, notwithstanding, from our position in other respects, to rank first as manufacturers of this modified form of iron. The rapid speeds attained on our railways, and the great strain which the machinery there, as well as on other occasions, is exposed to, has rendered increased strength of material, combined with lightness, an object of the highest importance. Metallurgists have thus been led to devise some more ready and less expensive methods of producing steel, this substance being, as is well known, possessed of the desired qualities, unequalled by any other known condition of iron. It is needless to dwell on the various projects which have been suggested for securing this desideratum, inasmuch as every one appears to have been driven out of the field by that last great discovery by Bessemer, the success of which still maintains for this nation its old position in an industry in which it has laboured so incessantly and to such good purpose. It is true in Prussia there exist gigantic steel-works—those of Krupp and others—where the process is carried on by methods confined, it is alleged, to themselves. Whatever these methods may be, they are not of that character to have prevented the directors of the establishments named from adding the converters of Bessemer to any appliances or modes of procedure of which they have the merit of being the original inventors. In concluding this endeavour to trace, in its main features, the progress of the manufacture of iron, I may be permitted to mention that during a personal acquaintance with the works of this and other countries, extending over twenty-five years, I can detect no change in the relative position of ourselves and Continental nations as iron manufacturers. No doubt abroad the production of this metal has increased immensely in late years, but this is due to circumstances entirely disconnected with any greater comparative proficiency than that possessed in former days. During the whole of the period named the existing ironworks were equal to similar establishments of our own, and, certainly, those which have been constructed of late have no pretensions whatever to be otherwise considered. The present depressed state of our own iron trade, and its recent extensions abroad, have probably countenanced the idea that the distress here has some connexion with the nature of the progress of the Continental manufactures. It becomes, therefore, not unimportant to ascertain upon what grounds such a supposition is based. The first question to which an investigator would address himself in such an inquiry is the powers possessed by different localities for obtaining the raw materials required in the works themselves. Immediately connected with this matter is the right of ownership in the minerals. In foreign countries generally this charge is one of trifling extent, which is far from being the case with ourselves, where, on a ton of pig iron worth about 45s., the manufacturer will contribute about 4s. for royalty to the owner of the soil; while, on the Continent, one-fourth of this sum will sometimes cover all that is levied for the right of working the coal and ironstone for the same quantity of iron. In spite, however, of these disadvantages, and of others connected with the extraction of coal in Britain, the purity of the produce of our collieries, and the favourable conditions under which it occurs, conduce to place this country, so far as fuel is concerned, in a position rarely approached by that of any European nation. When the ore itself has to be considered, much greater difficulty meets us than is experienced in the case of coal. In addition to price, we have to look to the percentage of iron they contain, and also to the widely different qualities of the metal they yield. Any very lengthened exposition of facts, however, would not only be tedious, but would lead to some confusion. We must, therefore, content ourselves with the statement that the advantages in cost and quality of iron ore possessed by Scotland, Staffordshire, Wales, and the West of England, are all to be severally met with on the Continent, and from the general statement we cannot even except the Cleveland iron field, for a similar deposit is extensively wrought in the Moselle district, and at a price fully below that paid in North Yorkshire. Conditions, however, immediately connected with the economy

of producing pig iron obtain in this kingdom, which are rarely met with abroad. The ore which has to be smelted is here either often got from the same strata which furnish the coal, or the span of country which separates the two is inconsiderable. The distances, on the other hand, which as a rule intervene between the coal fields and the iron mines abroad are so great as to prove a source of considerable outlay for conveying the produce of the one to the other. With regard to the application of science to those sections of our operations which are dependent on chemical action, viz., the blast-furnace and the puddling process, the ironmaster abroad, as here, can only lament how little chemistry has hitherto been able to effect for either. The labours of Karsten, Scheerer, Tunner, and others abroad, have thrown great light on the intricate and interesting problems connected with the working of our blast-furnaces. We have been informed by means of their investigations, and those of philosophers in this country and elsewhere, that differences we knew to exist between certain qualities of iron were due to minute quantities of silicon, phosphorus, or sulphur; but these experiments have never taught us how to separate, economically, those almost infinitesimal amounts of substances, and to rid our produce of which has defied their science and our practice. Both on the Continent and in this country, the success attending the use of the blast and puddling furnaces rests with the workman; and so far as waste of material, quality of produce, or any other test enables one to judge of the results, it is as absurd to impute any superiority to either side, as it is impossible to find a higher degree of science, where both British and foreign artisans are equally un instructed in regard to the true nature of the process under their control. It may be well, at the same time, for our own workpeople to know that, although we had the start in this particular field of industry, there is not one department, from rolling the finest wire iron and the thinnest tin plates or hoops, to turning out the largest rails or heaviest armour-plating, in which these operations are not performed quite as well by foreign labour as by the most expert rollers in the best mills in this country. Reverting now to the relative facilities enjoyed on the Continent and here in the manufacture of iron, it may be remembered that ours have been stated to lie in the possession of mines yielding coal upon more favourable conditions, and in the more convenient geographical distribution of our minerals. To the last may be added the easier transport of our manufactured produce to a seaport, due to the insular character of our country. Against this we have to set the lesser charge for royalties on coal and ironstone abroad, together with the fact, not previously noticed, that there railway transport is somewhat less costly than with us, reckoned for equal distances. The saving thus effected in France and other places cannot account for the disappearance which occurs to a great extent of the effect of those natural advantages placed at the disposal of the iron manufacturers of this kingdom. So far as a careful examination of ironworks producing above one-half of the collective make of France, Belgium, and the Ruhr district has enabled Mr. Lancaster the ironmaster, of Wigan, and myself to judge, this is due neither to greater science possessed by the ironmaster, nor to greater skill on the part of the workmen, but is wholly to be ascribed to the cheaper rate at which labour is obtained abroad than with us. To ascertain as exactly as possible whether the foreign artisan could, from surrounding circumstances, dispose of the work of his hands upon cheaper terms than persons of his own condition are able to do with ourselves, I made myself acquainted, while in Sweden, France, Belgium, and Prussia, with the cost of the necessities of life consumed by the working population. It is almost superfluous to say that the creation of additional industry abroad, and, above all, the equalising effect on prices by the introduction of free trade here, have entirely changed the aspect of affairs, and that, in consequence, provisions are at least 20 to 30 per cent. dearer to the foreign labourer than they were twenty years ago. Without going into details, it may suffice to say, that animal food is only 3 per cent. cheaper in the chief seats of Continental manufacture than with us—house rent and clothing are about the same in value with both. On the other hand, at the present moment wheat is fully lower in England, and our own workmen do not pay half the price charged to persons of their own class abroad, for firing employed for domestic use. Notwithstanding this almost perfect equality in the cost of the necessities of life, labour on the Continent is, in very many instances, 30 per cent. below the price it commands in this kingdom. This estimate is based on calculations where there is no room for any great difference in the nature of the work performed, common brick-making being assumed as one of the standards of comparison. In the manufacture of iron itself this difference is occasionally still more remarkable. Colliers, miners, mechanics, ironworkers, in short, every one engaged in the process appeared to be receiving 20 to 30 per cent. below the rates current in this country, and in some cases double, and more than double, the wages paid abroad are earned in our English ironworks. The ironmasters here have endeavoured to meet what would be an intolerable burden in the production of an article made up almost exclusively of labour by adopting means for reducing its amount, often considerably in advance of those met with in foreign establishments. After all this has been done, however, it leaves us to contend with an extra charge of at least 15 to 20 per cent. in the item of wages, which, in the majority of instances, will be found to anni-

hilate any advantage of position we may otherwise possess. It must be clear that when this country has to compete with foreign nations in articles involving a still higher amount of labour, such as steam-engines and other kinds of machinery, the difference in wages just alluded to acts still more prejudicially to the advancement of our national industry. To the political economist, the question of the future of our iron trade, from its magnitude, cannot fail to be one of great interest. The extent, also, to which steel has recently taken the place of iron in the arts necessarily confers upon this material a conspicuous position in any consideration he or the metallurgist may bestow on the subject. This becomes more necessary from the fact that only a very limited number of ores are capable of affording iron of the necessary quality for the production of steel by any of the processes now in existence. It is of importance therefore to know that even in Austria, Sweden, and Germany, where suitable mineral for this purpose does occur, it is found in quantities quite as limited in extent as prevails with us. In France, also, where preparations for manufacturing Bessemer steel on a very extensive scale are being made, large quantities of ore are required to be imported from Algeria and elsewhere to obtain that kind of pig iron which their own minerals alone are found incapable of supplying. The great strength, however, of our own position as iron manufacturers, it appears to me, must be sought for in those incomparable fields of coal which constitute so important a feature in our mineral wealth. I am very sanguine that the advantages thus secured to us will, notwithstanding present difficulties, maintain the iron trade among the most prominent of our national branches of commerce. This conclusion is arrived at from a consideration of the various circumstances connected with the use of coal and the means possessed by different nations in satisfying the constantly increasing demands this use creates. In Great Britain we raise annually something like 100,000,000 tons of this mineral, of which 10,000,000 tons are exported, and about 20,000,000 tons are devoted to the use of our ironworks, leaving thus 70,000,000 tons for consumption in other descriptions of manufactures, purposes of locomotion, and for domestic use. In France and Belgium together, less than one-fourth of our production is obtained, and this only by great exertions being made to obtain the largest possible quantity their mines are capable of affording. After satisfying the requirements of the ironworks of these two countries, not much over 15,000,000 of tons would remain for carrying on those operations in which, with a smaller population, we are consuming seventy millions of tons of coal. Now, when we remember the various purposes to which coal is now applied, and when even a considerable augmentation of price will not preclude its use, we must at the same time perceive the serious effect any great change in the value of fuel must exercise on the production of an iron railway bar requiring five or six tons of coals for its manufacture. In reality, this disproportion between the value of coal and iron as compared with this country is already perceived abroad, where, notwithstanding greater mining difficulties than we have to contend with, fuel commands a price sufficient to cover this and also leave a greater margin of profit than falls to the share of the coal-owner in this country. Favoured thus, as we undoubtedly are by Nature, there seems nothing wanting for our success in this noble branch of manufacturing science than a continuance of that still unflagging spirit of enterprise on the part of the masters, and the exercise of that operative skill on the side of our workmen which is still unsurpassed in any iron-producing country of Europe, but in this alliance a correct knowledge by both of the competition we have to meet, and a thorough belief in the inseparable union of the interests of each, is indispensable.

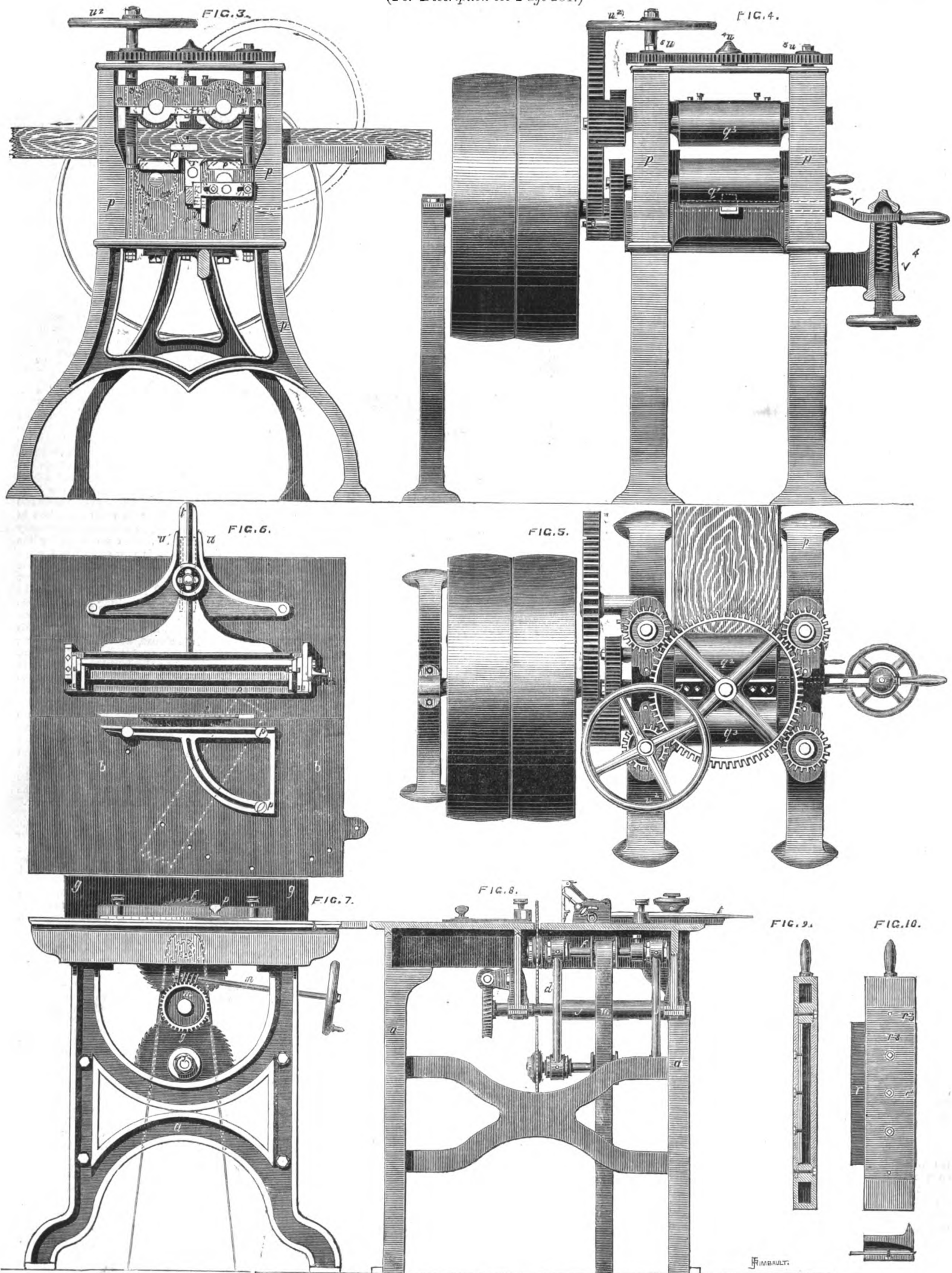
THE NEW YORK PANAMA RAILROAD.—The overthrow of President Mosquera, in New Granada, has been rapidly followed by a cession on the part of the new authorities of that republic of the long-sought extension of the privileges of the New York Panama Railroad Company. Under the original contract the rights conferred upon the company would expire in 1875, but a prolongation has now been granted for 99 years from that date. For this the company are to pay 200,000*l.* in gold immediately, and an additional 50,000*l.* per annum until the expiration of the term. The contract, which has been signed by the Executive and ratified by Congress, also grants to the company the island of Manzanilla in fee. The company, it is said, will now extend the road two or three miles out into the Bay of Panama, so that the largest ships and steamers may load and discharge alongside the track. They will also immediately make other improvements, necessitating in all the outlay of about 500,000*l.* The new privilege of the company is exclusive, no company being allowed to make any road or canal across the Isthmus without their consent or the payment to them and the republic of such amount as they may demand for permitting such construction.

THE PLACENTIA AND CAPE BRETON TELEGRAPH CABLE.—It is announced from Cape Breton that the new cable between Placentia, Newfoundland, and North Sydney, Cape Breton, has been successfully laid, thus completing a new route from Nova Scotia to the Atlantic cables, by which the dilapidated Newfoundland land lines are avoided.

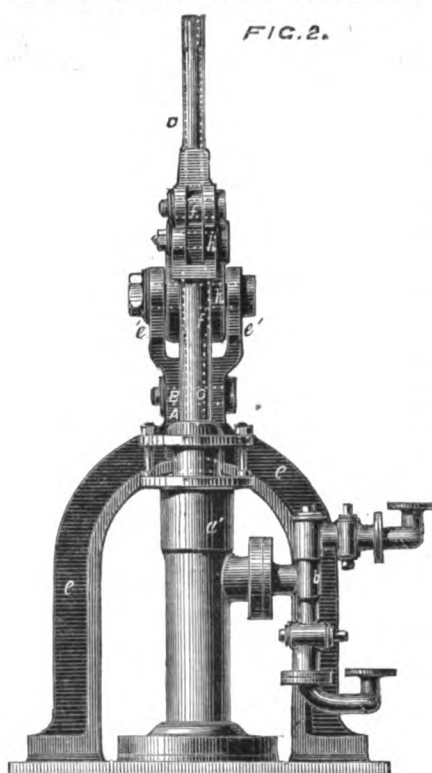
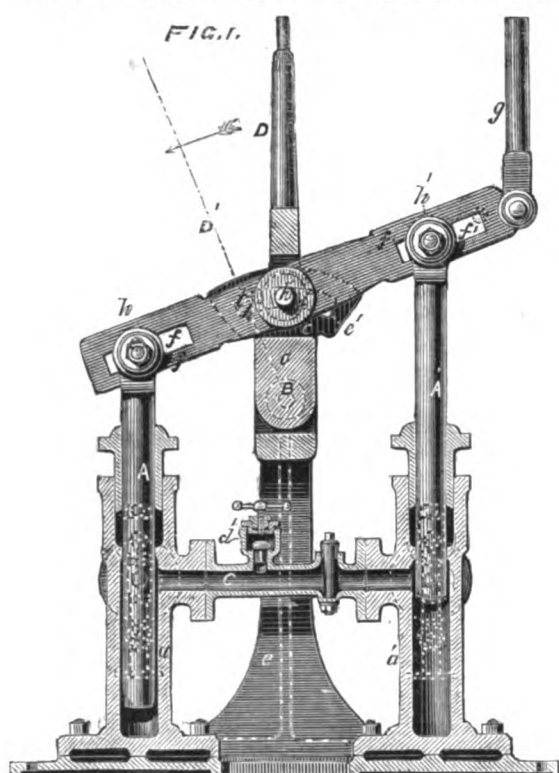
BORDEAUX.—In the course of 1866, the Bordeaux chamber had an interview with the Emperor Napoleon at Biarritz, in order to detail to his Majesty the wants of that great port, and to solicit the execution of the works required to promote its development. These works have just been decreed, and in a few years it is expected that Bordeaux will offer to the commerce of all nations facilities on the banks of the Gironde similar to those existing on the banks of the Thames and the Mersey.

WHITNEYS WOOD WORKING MACHINES AT THE PARIS EXHIBITION.

(For Description see Page 281.)



DIFFERENTIAL PUMPS FOR HYDRAULIC PRESSES.



DIFFERENTIAL PUMPS.

THREE weeks ago, we mentioned amongst our notices of "Recent Patents" an ingenious arrangement of pumps for hydraulic presses designed by MM. Pierre du Rieux and Edouard Roettger, of Lille, and of these pumps—differential pumps as they are called—we now give engravings. According to this plan, two pump cylinders of equal diameters and length of stroke, and fitted each with suitable suction valves, are connected by a pipe to which the discharge pipe and the valves belonging to it are attached. The plungers of the pumps are also connected so that when one is raised the other is lowered. If motion be now communicated to the pump-handle to actuate the plungers, the liquid will pass alternately from one pump barrel to the other, and no liquid will be sucked into the pump nor discharged from it; but if the position of the fulcrum on which the pump-handle or lever works be changed so as to be brought nearer the line of axis of one or other of the pumps, the length of stroke of one piston will be increased, and that of the other piston will be diminished, and if the pump-handle be now worked a quantity of liquid will be discharged at each stroke of the pistons equal to a column of liquid of the same diameter as the plungers, and equal in height to the difference between the lengths of their strokes. By varying the relative length of stroke of the two pistons the quantity of liquid discharged may thus be readily adjusted at pleasure, and the pressure of the liquid discharged from the differential pump will be inversely proportionate to the quantity discharged. It will be readily understood also that, by suitably varying the position of the fulcrum of the pump-handle or lever so as to increase or diminish the relative lengths of stroke of the two pistons, a given power acting on the said pump-handle may be made to communicate at pleasure varying pressure to the liquid discharged, or a varying power (such as manual or animal power) may be made to produce a constant pressure of uniform intensity.

In the arrangement shown in our engravings, aa' are the two pump-barrels of equal size, and each provided with valve boxes, bb' , and plungers, AA' , these barrels being connected by the tube, c , to which the box, at , containing the discharge-valve is affixed. A frame or standard, ee , provided at its upper end with slides, $e'e'$, curved to an arc struck from the centre, B , serves as a guide for the fulcrum, h' , on which the beam for working the plungers oscillates, this fulcrum being carried by the link, C , furnished with the lever handle, D . Motion is communicated to the pistons, AA' , by means of the beam or lever, f , actuated by a steam-engine or other suitable motive power by means of the rod, g , jointed to one end of it. The piston heads are connected to the beam, f , by pins, h , traversing the piston heads and slots, $f'f'$, in the beam, the beam being capable of a sliding motion on the pins, h . On the centre of the beam, f , is a boss, f^2 , which boss passes through the link, C ; and a pin or bolt, h' , passing through the curved slides, $e'e'$, the links, C , and the boss or centre, f^2 , of the beam acts, as we have already stated, as fulcrum upon which the beam, f , is made to oscillate.

By moving the handle or lever, D , of the link, C , nearer to the line of axis of one or other of the pumps, the bolt, h' , will be correspondingly shifted in the slides, $e'e'$, drawing the beam, f , along with it. Supposing the lever, D , were moved in the direction of the arrow, and had assumed the position indicated by the dotted line, D' , the centre or fulcrum, h' , of the beam, f , would occupy the position indicated by the circle, h , and the length of stroke of the piston, A' , would be increased, whilst that of the piston, A , would be diminished. A quantity of liquid would then be discharged at each stroke of the pistons equal to a column of liquid of the same diameter as the pistons, and equal in height to the difference between the length of stroke of the two pistons; and it will be readily understood that by moving the handle or lever, D , in one direction or the other, the

length of stroke of either piston may be correspondingly increased or diminished, and the quantity of liquid discharged may be readily adjusted according to the extent to which the lever, D , is moved from its vertical position. When the differential pump is used for forcing liquids, the pressure of the liquid will be inversely proportionate to the quantity discharged, and may be regulated at pleasure by changing the position of the axis or fulcrum, h' , in its slides, $e'e'$, by moving the lever, D , and, if required, this lever may be connected with self-acting apparatus, in order that its position, and consequently the pressure of the discharge from the pump, may be varied from time to time to suit the purposes to which the latter is applied. The arrangement is, altogether, a very simple and ingenious one.

THE PROFESSIONAL INITIALS.

TO THE EDITOR OF ENGINEERING.

SIR,—It is unfortunate that there should exist a class of men who, without attainments to justify their presumption, and without the shadow of a claim acquired by professional training or practice, assume the title of civil engineer, and under that guise manage to inflict considerable damage on the public, not to speak of the discredit they bring upon the profession.

Without any idea of being personal, I could indicate several offices where, to my knowledge—and unfortunately I speak from experience—the title referred to is applied to designate the business of a measurer, or petty surveyor, and even of a general commission agent.

The chief evil resulting from such establishments lies in their inducing young men to enter as apprentices, in most cases exacting a considerable premium, and turning them out thorough qualified paper engineers, to forsake in disgust a profession they had, in reality, never entered, or to begin another pupillage, with less ardour and at great disadvantage.

It is unfortunate that such a miserable class of engineers should be tolerated; and, indeed, there is little ground for hope in the engineering future unless some means be taken to render the profession more select. Perhaps the only way in which that can be effectually done will be by obtaining powers to license the members by granting a diploma, as in the other professions.

The Institution of Civil Engineers is the proper body to take the matter in hand, and it is sincerely to be hoped that that honourable body will exhibit its zeal in the interests of the profession by moving in the matter before long.

Such a course would be more worthy of the reputation of the Institution, and more consistent with the best interests of the profession, than the unworthy attempt it has lately been making to shackle the development of real professional ability.

Hoping you will be able to afford space for this in an early number of your valuable paper, and that it may help to attract attention to a crying evil, I enclose my card,

And remain, Sir,

Yours most faithfully,

N. B.

LOCOMOTIVE-BUILDING AND RAIL-MAKING IN FRANCE.—The Creusot Works have received an order for eighteen locomotives for goods trains from the Southern of France Railway Company, and the engines will have eight wheels coupled and will be fitted with steel boilers. It is stated that the Creusot Works have also contracted for eighty locomotives for Russian lines; it is added that the terms are low, and that obligations have to be accepted in part payment. These engines were also tendered for by a number of English firms. The Terrenoire Company have just accepted an order for 2000 tons of Bessemer steel rails for the Eastern of France Railway Company, at the rate of 13*l*. 11*s*. 2*d*. per ton, delivered at Saincaige, which represents about 12*l*. 17*s*. 6*d*. per ton at the works.

FRENCH COKING OVENS.

FOR those who doubt that British colliery proprietors will have something to learn from their neighbours on the Continent during the next few years, a short notice by one exhibitor in the park of the Paris Exhibition would be a useful acquisition. This is a small circular issued by Messrs. Carvés and Co., of Saint Etienne, in France, for distribution amongst the visitors to the show of articles exhibited by the Société de Carbonisation de la Loire. Messrs. Carvés and Co. state that, in the usual process of coking, the gases emitted by the coal are burnt, or otherwise thrown to waste, and with these a great quantity of different volatile products capable of being made use of in a variety of manners are carried away and destroyed. The only purpose to which the combustion of these gases is used is the development of sufficient heat for supporting the coking process in the adjoining masses, an end which may be obtained by the proper employment of a small and less valuable fraction only of the total mass now wasted. The coking ovens of the Société de Carbonisation de la Loire, which have been at work now for nine years, and which convert about 80,000 tons of coal into coke annually, do not burn the gases evolved by the coal. These gases are drawn off through closed channels and cooled, so as to condense the tar and ammoniacal liquids, and thereby purify the gas, which afterwards can be used in the same manner as the gas obtained at special gas-works. From the tar and liquids obtained in this manner a whole series of chemical products is made, all of which are exhibited, together with the specimens of coke made by Messrs. Carvés and Co. These are benzine, naphthalene, sulphate of ammonia, a whole collection of artificial manures; some colouring substances, and silk dyed with them; in fact, a whole treasury of valuable and marketable articles, all produced from those volatile products which are wasted by tons in weight at so many places in this country. Messrs. Carvés and Co. state that the net profit which they draw from these secondary products produced by each ton of coal coked in their ovens is 2*fr*. 40*c*. They add to this the calculation that all France, consuming four million tons of coke, corresponding to about three and a half million tons of coal, of which the volatile products are wasted, loses between twelve and thirteen millions of francs annually from this cause. It is likely that some portion of the losses included by Messrs. Carvés in their estimate belongs to this country, which supplies coke in large quantities to France.

THE BARROW HEMATITE STEEL WORKS.

THE Barrow Steel Works are at this moment, and in their present state, the largest Bessemer steel works in this country, and the largest steel works but one in the world, yet so far as these works are laid out and very nearly completed at present, they form only one half of the enormous establishment which the Barrow Steel Company intend to erect at Barrow. This half contains ten Bessemer steel converters, of which four are capable of holding charges of 5 tons each, and are arranged in two pairs, each pair occupying a separate pit, whilst the six other converters—constructed to take a charge of 7 tons each—are placed in groups of three in two larger pits. Estimating each vessel at an average of four charges a day, which is below what could be done on an emergency, the capability of production at the present time, when only seven converters are in working trim (the last three being fast approaching their completion), would represent a power of production of nearly 1000 tons per week, a production which will be increased to 1500 tons very shortly. There are, of course, no Bessemer steel works regularly working up to the full power of production of its converters, but still this latter is the only proper element for comparing establishments of the kind. Another point of comparison, however, is the largest-sized ingot which the plant can produce, and in this respect we find that at Barrow the three 7-ton converters which can discharge their contents into one ladle, and are thus capable of producing an ingot of 21 tons, give the power of turning out the largest sized ingot that can be made in this country with the existing Bessemer steel plant.

On the 19th instant the Barrow Works were visited by the guests of the Furness Railway Company, who attended at the opening ceremony of the Barrow Docks. Mr. J. T. Smith, the manager of these works, received this numerous party, which was led first to the blast furnaces and thence to the steel works proper, entering the latter at the end which contained the converters, and then following the progress of the

steel through the series of hammers and rolls in the same straight course in which the materials pass through the works in the course of their manufacture. Of the eleven blast furnaces now existing at Barrow, ten are at present in blast, whilst the oldest furnace, No. 1, is in course of reconstruction, after having been in continuous service an unusually long time. On pages 175 and 217 of our third volume, we described these blast furnaces and their working, so that we now must confine ourselves to a reference to this previous description. Of the steel works we have also given a detailed description in our former volume, and we shall now only notice some additions made since the time at which that description appeared. With regard to these, we consider as one of the most important the construction of Mr. Ireland's cupolas for remelting the pig iron, and of this we give some further account on the present page. The plate-mill, which we described some time ago, is now working with great success, making boiler-plates, which, with regard to beauty of surface and quality of material, are said to be equal to the best steel plates made anywhere. This powerful mill has been constructed so as to be capable of rolling steel armour-plates, but it has never been made use of for this purpose, as the value of steel as a material for armour-plating has not yet been established. The reheating furnaces throughout the whole forge are Siemens gas furnaces. The generators are placed in two parallel rows outside the building, and two large gas-pipes are carried all along the side walls of the large sheds at a height of about 12 ft. above the ground, branching off to all the different furnaces as required. The Siemens furnace has been very successful at these works. According to a statement made by Mr. J. T. Smith, these furnaces, as compared with the ordinary welding and reheating furnaces save in cost of repairs fully as much as the royalty for their use amounts to, so that all the economy of fuel and the convenience of management must be considered as a clear gain to their users. The Siemens furnace has also another advantage, which, in practice, is very important, viz., the waste of steel by oxidation is much less in it than in the common furnace, and the chances of overheating or burning the steel are also less, since the temperature can be regulated with great facility, and is maintained uniform all over the area of the furnace—conditions which do not exist in the common reverberatory furnace fired with coal. Four new steam-hammers, two by Messrs. Thwaites and Carbutt, and two by Messrs. Musgrave and Sons (Condie's patent), have been added to the plant at the Barrow Works. They are all of a moderate size, as the original intention of going in for the manufacture of very heavy forgings has been given up from commercial reasons. The hammers of Messrs. Thwaites and Carbutt have wrought-iron frames and are similar in construction and appearance to that exhibited by the same firm in Paris. A new circular saw, 6 ft. in diameter, for cutting off the crop ends of steel rails, was started for the first time on the occasion of the visit on the 19th inst. This machine is an improvement on the design of the rail-cutting saw mentioned in our first description of these works. It has been designed by Mr. E. Moreton, the chief engineer of the Barrow Steel Works, and made at those works. We expect, at an early date, to publish a drawing of this machine, and will therefore postpone the description of its details. The beautiful testing-machine, on Mr. Kirkaldy's plan, is now in regular employment for testing the products of the Barrow Works. This machine is the make of Messrs. Greenwood and Batley, Leeds. It has a cast-steel hydraulic cylinder, made by Messrs. Naylor, Vickers and Co., of Sheffield, and the whole machine is of excellent workmanship and finish. The tests made with this machine and the samples of tested steel placed all round it cannot fail to impress every visitor with the conviction of the excellence and reliability of Bessemer steel in every form and in all modes of its application.

BESSEMER STEEL PLANT AT BARROW.

The new set of converters at the Barrow Hematite Steel Works was brought into operation a short time ago. These converters are placed together in groups of three in one pit, each converter being capable of holding from 7 tons to 8 tons of liquid metal. The pinion fixed to the trunnion for turning each vessel is worked by a vertical rack and hydraulic ram, in lieu of the horizontal rack usually employed, this alteration allowing the vessels to be brought closer together, and occupying less space on the floor. The original idea in planning these sets of converters was to work the liquid pig iron from the blast furnaces direct by tapping it into a ladle placed on a railway truck

and transporting it to the converter while in the liquid state. It would have been possible in this manner to dispense with the remelting furnaces, which are usually placed behind the converter, and sufficient room was consequently found for placing a third converter in each pit. After some experiments made at the Barrow Steel Works, it was found, however, that the quality of pig iron tapped from the furnaces is not sufficiently uniform and regular to be at all times relied upon for the Bessemer process without any further control and rectification, and that, in consequence, the quantity of waste or inferior material which was likely to accrue from direct working would have been more than a balance to any economic advantages which could have been derived from the saving of the remelting process. The idea of working direct has, therefore, been given up, and another method resorted to. The Bessemer pig iron tapped from the furnaces is, after each pig is broken and examined, divided over a very large surface in many heaps, so that each single heap contains no more than one half of a pig, or about 2 cwt. of iron from one charge. The virtual composition of each heap of pig iron stored in this manner is the average of a very large number of casts divided over a very long time of working. The occasional productions of irregular or more or less unsuitable iron disappear in this mixture, and a kind of general average quality of pig iron is obtained, which in reality shows an amount of uniformity of character and a regularity in its chemical composition which is far superior to the unmixed make of any blast furnace, however well and carefully conducted. The Bessemer pig iron sold by the Barrow Company to Crewe, Sir John Brown and Co., and to some other great steel works in this country, is taken from the same mixed stores. The pig iron used in the steel works at Barrow is remelted in Ireland's cupolas. There is one of these cupolas placed behind each of the converters, and they are blown by the spare blast of the great blowing-engines which work the blast furnaces, this blast being carried to a considerable distance in a large pipe. The pressure of blast in the cupolas is about 1 lb. per square inch, and the charges of 7 or 8 tons are melted down with the same coke as is used in the blast furnace. The consumption of fuel, including the starting of each charge, is 2 lb. of coke per ton of pig iron, and the waste of iron, as compared with the air furnace, is reduced considerably. The cupola is by this experience found to afford a most important economy in the making of Bessemer steel, and the quality of the produce is in no way impaired by its use. Mr. Ireland's cupolas were first employed for the Bessemer process in the Mersey Steel and Iron Works, at Liverpool. Another cupola, constructed on Woodward's patent, is employed at the Manchester Steel and Plant Company's works; and at the Neuberg works, in Austria, a cupola worked with charcoal was employed for the same purpose before these works succeeded in working from their blast furnaces direct. At the Barrow Steel Works the spiegeleisen is also melted in a small cupola, there being two of these latter provided for each set of three vessels. A special blowing-engine is to be constructed shortly for working all these cupolas so as to avoid the necessity of carrying the blast to the great distance through which it is now conveyed.

BRICK-MAKING KILNS.—At Barrow-in-Furness new brick-works have been recently erected by Mr. Woodhouse, the builder employed by the Hematite Iron and Steel Company for all the brickwork required in their extensive establishment. Mr. Woodhouse has erected one of Messrs. Platt Brothers' brick-making machines, capable of turning out 20,000 bricks per day. These are dry-clay bricks of a very superior quality. For burning these bricks a large kiln has just been completed on Hoffmann and Licht's patent principle. This kiln is of an elliptical form, and has twenty-four compartments, divided from each other by movable partitions. The products of combustion, and heated gases from the chambers where the burning of the bricks is in full operation, are led successively through chambers containing bricks in earlier stages of the operation, so that the gases come in contact with less intensely heated groups of bricks in succession, until at last they pass over green bricks, which they dry and prepare for the process of burning proper. The heat is in this manner utilised more completely, and an important economy of fuel obtained in burning bricks. The Hoffmann kiln offers, in fact, to the brick-maker precisely the same advantage which the Siemens furnace has been found to give to steel-makers and other manufacturers employing the latter. The Hoffmann kiln is coming into very general use in this country, there being a considerable number of such kilns now at work, and a still larger number in progress. The first Hoffmann kiln erected in Scotland, we believe, is that of the Merryflat Brickworks, Glasgow.

COAL IN FRANCE.—It is worthy of note that the imports of English coal into France this year have increased, while those of Belgian coal have decreased. Thus, in the first seven months of this year, the imports of Belgian coal amounted to 1,868,000 tons, as compared with 2,112,000 tons in the corresponding period of 1866. On the other hand, the imports of English coal increased to 1,228,510 tons to July 31, this year, as compared with 1,074,124 tons to the corresponding date of 1866.

NOTES FROM INDIA.

THE expenditure of the municipality of Bombay during 1866 amounted to the enormous sum of 577,480*l.*, and the income to 536,826*l.*

Colonel Rundal, late chief engineer to the East India Irrigation and Canal Company, has been appointed to the newly created office of chief engineer and joint secretary to the Government of Bengal in the irrigation branch of the Public Works Department.

The prospects of the cotton crops in Central India are reported most favourable. The plants, generally, are in excellent condition, except in some of the low-lying districts, where damage has been done by the rain.

Under instructions from the Secretary of State, it is notified that officers desirous of studying at Roorkee, with the view of qualifying for the Public Works Department, and eventual admission to the Staff Corps, will not be allowed to enter on the course until they have completed the prescribed period of regimental duty, as laid down in the Staff Corps warrant, viz., three years—two of which must have been spent in India.

Arrangements are being made by the officiating Director-General of Telegraphs in India for the supply, for the use of Government, of a daily telegram from London, which, in addition to being forwarded to the Viceroy, at Simla, is also to be supplied to all the local Governments and Administrations.

The Government have determined on erecting two telegraph houses in the premises of the Military Male Orphan Asylum, Madras, the line of communication running from one house to another, for the purpose of instructing the lads of the institution in that line of business preparatory to their admission to the Government Telegraph Department. They will be instructed by one of the officials of the department appointed for that purpose.

A building is to be erected in Calcutta for the Telegraph Department, between the new Post Office and the river; the new Government offices are being planned on a site near Dalhousie-square. The works at the new High Court are progressing rapidly. The lower story is to be completed and fit for occupation before the walls are carried up for the second story. The carving of the capitals of the twenty-seven pillars, which are of Caen stone, is stated to be really very fine.

The Meerut and Delhi line of Railway will not, it is now stated, be opened before October.

There were 136 railway accidents in the Bombay Presidency during 1866, as compared with 95 in Bengal. The killed and injured number 157 in the former Presidency, and 95 in the latter.

The Bengal Government has decided upon the ejection of 8000 villagers from their homes in the gamo, or hamlet, of Rishra, to make place for the erection of an engine station of the East Indian Railway.

The widow of Mr. Fenwick, one of the victims of the Nimboru accident on the Great Indian Peninsula Railway, is about to sue the company for damages to the amount of 60,000 rupees. This will be the first action of the kind in India.

The shareholders of the East Indian Railway have determined not to build a bridge for their railway across the Hooghly. The necessity for a bridge over the Hooghly has long been felt in Calcutta, and strongly urged by the public there.

The Rajpootana Railway will, it is expected, most probably run from Neemuch direct to Delhi, passing through the territories of Kishnaghur and Ulwar, and following for the first half of the route the old road from Neemuch to Ajmere.

There have been serious floods on the south-western coast of India. The railway has been damaged at the 377th mile by unusually strong freshes, which caused the river Thootu to overflow between Puttamby and Cootypooram, and the flood carried away a portion of one of the railway bridges. The company have been obliged to stop running trains between Puttamby and Bepore.

The open section of the Delhi and Lahore Railway from Meerut to Ghazeeabad has given way in one place, owing to heavy rains. Mr. H. Stone, the district engineer, who went on an engine to survey the line, has died from the effects of injuries received from the engine falling into the gap within five miles of Meerut. The line, though new, ought to have been better constructed.

The *Central India Times* relates the following amusing anecdote: "A branch in the Madras Presidency runs through a wild region, the inhabitants of which are unsophisticated savages, addicted to thievery. The first day the line was opened a number of the Arcadians conspired to intercept the train and have a glorious loot. To accomplish their object they placed some trunks of trees across the rails; but the engine-driver keeping a very sharp look-out, as it happened to be his first trip on the line in question, descried the trunks while yet they were at a considerable distance from him. The brakes were then put on, and when the locomotive had approached within a couple of feet of the trunks, it was brought to a standstill. Then, instantaneously, like Roderick Dhu's clansmen starting from the heather, natives, previously invisible, swarmed up on all sides, and, crowding into the carriages, they began to pillage and plunder everything they could lay their hands upon. While they were thus agreeably engaged, the guard gave the signal to the driver, who at once reversed his engine and put it to the top of its speed. The reader may judge

of the consternation of the robbers, when they found themselves whirled backwards at a pace that rendered escape from the carriages wholly impossible. The few who attempted it were killed on the spot. Thus were our Arcadians nicely caught; and as they were transferred from this novel man-trap to the jail they were, no doubt, convinced that this 'fire-bandy' can move progressively and retrogressively with equal facility."

LORD REDESDALE AND MR. BRASSEY.

TO THE EDITOR OF ENGINEERING.

SIR,—I ventured to conclude a former letter to you on this subject by a mild hint that the exhibition which Lord Redesdale has lately been making of himself before an admiring public is not altogether without parallel, if not in mere matter-of-fact prose, at least in poetical romance.

Since then, however, the noble lord has adopted means of making good his claims to public admiration that entirely mar this striking parallel. No doubt Goldsmith's hero succeeded in astonishing, and even (in a few cases) scaring his beholders; but then there is no record that he slandered their characters as well, and I therefore hasten to offer an apology to his illustrious memory for having in any way connected it with Lord Redesdale's recent proceedings.

Having been driven from one absurdity to another, notwithstanding his astonishingly reckless and wholesale charges against several leading gentlemen of different professions, his lordship has seen fit to wind up with as scandalous an attack as he could possibly have made on one who holds a prominent place in the engineering world.

This is matter that so deeply and widely affects every member of this profession, that I am sure you will lend your powerful aid to expose such conduct to the reprobation and contempt it so justly merits.

I think the shortest and best way of placing the matter before your readers is to quote entirely a letter which appears in the *Times* of the 21st inst.:

TO THE EDITOR OF THE TIMES.

SIR,—Some days since Lord Redesdale insinuated in a letter to you that I had been obliged to resign my position as engineer to the Great Eastern Railway Company, in consequence of some discreditable discoveries by the late committee of investigation.

By your indulgence I was enabled to show the entire untruthfulness of this statement, but Lord Redesdale now thinks it right to attack me on another side, and in his letter to you of the 18th inst. he broadly states that, being remunerated by a percentage on the cost of making the Dunmow line, I allowed prices enormously in excess of the original estimate, and he more than insinuates that this was done for the purpose of increasing the amount of the remuneration I was to receive.

Could there be anything more disgraceful to a man than this, if true, and can there be anything more disgraceful than to make such a charge without foundation? and yet that is what Lord Redesdale has done.

It might well have been that my remuneration had been fixed at a percentage on the cost of these works, that being a very common, perhaps the usual mode of paying for engineering work; and Lord Redesdale well knows how difficult it would have been for me, in that case, to have cleared myself of the suspicion he has raised; but it is not true that I have been paid, and that it ever was intended that I should be paid, by a percentage on the cost of the works. My remuneration was fixed at a certain sum per mile of railway, and would have been the same to a shilling whatever the line had cost. As to Lord Redesdale's assurance that I will thank him for the opportunity of explaining this, I have to say that no person can like to be publicly slandered for the mere gratification of refuting the slander.

I blush to have to defend my character from such imputations; but it remains to be seen whether Lord Redesdale is to be allowed with impunity to trifle in this manner with the reputation of others; and I will at once place the matter in the hands of my solicitor to have this decided.

As to the clause in the Act of 1865 limiting the Great Eastern purchase money to 80,000*l.*, which Lord Redesdale assumes to have been the result of the directors' confidential communications with me, I can only say that I knew nothing whatever about the clause in question before this controversy began; and had I been in any way consulted about it, I would most certainly have pointed out that the sum named was not sufficient.

The increased cost of the line, as has been already explained in the course of this correspondence, arises from the additional works and stations required to make it equal to other Great Eastern main lines; by the purchase of land for a double line; and by the large amount of interest payable to Mr. Brassey on account of his not receiving payment until the completion and opening of the line for traffic. Mr. Brassey has also further pointed out that the prices I fixed with him were similar to those of contracts which he had obtained from the company by public competition.

These facts, however, Lord Redesdale chooses entirely to ignore in his unaccountable anxiety to attack my character.

I am, Sir,

Your most obedient Servant,

ROBERT SINCLAIR.

4, Westminster-chambers, S.W., Sept. 20.

This letter places the matter I refer to in so clear a light that comment from me upon it is unnecessary; a few words about its bearing on the profession generally may not, however, be out of place. First of all, then, I notice the circumstances which have reduced such a gross and unfounded charge possible, as well as the object it was supposed to effect.

Even Lord Redesdale, it would appear, can no longer deny that the insertion of the sum of 80,000*l.* in the Act of 1865 was an oversight (as mentioned in my former letter) which would not have taken place had proper attention been called to facts. Those who remember the very strong language which the noble lord has used on this particular point will appreciate the tacit admission (implied in the new theory) that Mr. Brassey was right about it after all. It would further appear that the circumstance of

40,000*l.* beyond the authorised capital being due to Mr. Brassey under the so-called "illegal" contract of 1862 is also now admitted.

This being so, persons who did not know the wonderful resources of the noble lord might have supposed the matter would have ended with apologies from him all round. Instead, however, of this, the startling theory is published to the world that the extra cost of the line may be explained from the fact of the engineer making the prices as high as he can, in order that his commission may be proportionately large! Mr. Sinclair may well say, in his reply, that nothing could be more disgraceful than this, if true. For the sake of putting a few paltry pounds in his own pocket, the engineer is now accused of having thrown liabilities of many thousands on his employers!

Mr. Sinclair is to be congratulated on the absolutely conclusive answer he has happily been able to give to this mendacious insinuation. In most cases, however, it is well known that no such conclusive answer could have been given, a commission on the cost of the work being the most usual form of payment amongst engineers.

Let it now, however, be thoroughly understood by every engineer in future, that when his works, no matter however obvious the true cause, should happen to cost more than the contemplated amount, there is a Redesdale ready and willing to hold him up to the world as having caused this to enhance his commission; and, understanding this, he will understand Lord Redesdale's last and most unworthy mode of explaining a matter that is patent and open to the eyes of every one who chooses to use them.

As a closing instance of the desperate straits which the noble lord is driven to, in order to make it appear that his opponents are what he represents them to be, I may mention that he lays a sinister emphasis on Mr. Sinclair's having undertaken such work as the making of the Dunmow line "when he was receiving a fixed salary" from the Great Eastern; and this he does after Mr. Brassey has published in one of his letters a Great Eastern board resolution ordering Mr. Sinclair to take this very position!

I feel I must now leave the noble lord to the judgment of all right-minded people, not forgetting Messrs. Bidder and Sinclair's solicitors.

I am your obedient Servant, M.

Westminster, Sept. 23, 1867.

DRILLED & PUNCHED HOLES.

TO THE EDITOR OF ENGINEERING.

SIR,—It has often appeared inexplicable to me that whilst engineers now-a-days so generally insist on the importance of drilling instead of punching the rivet-holes in girder and boiler work, the subject has not received the same amount of attention at the hands of our naval architects.

Some years ago I chanced to see a large Messageries Impériales steamer which had struck upon a submerged rock in the Mediterranean, the impetus of the vessel being so great that she had not been brought to a stand until pretty nearly evenly balanced on the rock.

We are taught that a sea-going ship may be considered in the light of an immense girder, which, under varying circumstances, may be called upon to carry a load in the middle whilst supported at the ends, or vice versa; but it was evident that either the rules upon which this vessel had been constructed, or the workmanship, or both, were at fault. I am disposed to think both, for no sooner did she begin to fill than she parted amidships, and settled down fore and aft in deep water (I hope I am correct, or at least understandable, in my nautical phraseology). The rents, of course, commenced at the bulwarks, and gradually extended downwards, choosing, however, the lines of rivet-holes. No doubt this would have been the case under any circumstances, and that it is impossible by any system of rivetting, except, perhaps, thickening the edges of the plates, to preserve the full strength of it. The result of the experiments of Mr. Fairbairn and other well-known engineers would appear to prove that we cannot, in any appreciable degree, avoid the loss of strength occasioned by diminishing the sectional area of the plate; but, although they show that this loss is further unnecessarily increased by forcing out the portions of iron by means of a punch, instead of cutting them out with a drill. I am not aware that there have been any satisfactory experiments made to test the effects of the subsequent operation of drifting, which all punched holes must undergo.

The manager of one of the largest shipbuilding yards in the north told me the other day that it was their practice to punch the rivet-holes an eighth of an inch less than they were intended ultimately to be, and to make the two holes (in a manner) correspond, by forcing through a steel drift the size of the rivets. One advantage attends this plan, that is, it tests the quality of the iron. None but a tough strong iron, with a hole anything like within its own diameter of the edge of the plate or bar, would stand such fearful treatment as this. But whilst there may be no crack that even the sharp eye of the inspector can detect, who shall say how many or how few more blows would suffice to produce one, how nearly the strength and tenacity of the iron are exhausted, or how fit it is to fulfil its proper functions as a portion of the vessel?

Taking into consideration the inevitable loss of strength occasioned by the diminished sectional area, the avoidable loss caused by punching, and, as I believe, the still greater loss which the drifting process entails, is it safe to assume in many cases that there is 30 per cent. of the original strength of the bar or plate left? To remedy the two last-named evils, I would suggest the practicability of drilling and countersinking at one operation the rivet holes after the plates are placed in position on the sides of the vessel, simultaneously through skin and framing. This could be accomplished by a portable multiple drilling-machine, having its own engine attached, of course supplied with steam by means of a flexible or jointed steam-pipe.

The construction of such a machine with six, eight, or ten drills of readily variable pitch "presents no mechanical difficulty." It would not be an expensive machine, and could be easily applied to most parts of the shell of the vessel, whilst an ordinary radial drill, also with its own engine, could be applied to the more inaccessible parts.

The plan might be somewhat more costly than punching, but so is drilled girder work, and the stability of a bridge is not of more importance than the strength of a ship.

If this suggestion has not been made before, I shall be glad if you think it worth publishing, and subscribe myself,

Yours, &c.,

G. HUTCHINSON.

Skerne Iron Works, Darlington, Sept. 21, 1867.

STEAM HAMMERS.

TO THE EDITOR OF ENGINEERING.

SIR,—I observe that Mr. Lowthian Bell, in his paper on "The present State of the Manufacture of Iron in Britain," read at the late meeting of the British Association at Dundee, and published in *ENGINEERING* of this day, says, "The steam hammer, a French idea, it is said, originally, but indebted for its practical application here to Nasmyth."

The steam hammer was invented by James Watt, and described in his fifth patent in the year 1784.

On the 6th June, 1806, William Devereil, of London, patented a steam hammer in which the compressed air at the top of the cylinder was made to give additional force to the blow.

In 1838-39, James Nasmyth revived the idea of the steam hammer.

In 1839, Francis Bourdon, of Creusot, invited Nasmyth, saw his plans, and, returning to Creusot, set up one.

In 1842, Nasmyth visited Creusot, and saw this hammer, and, on his return, patented the Nasmyth-Bourdon hammer in his own name.

Since that time, Morrison, Condie, and others, have brought out modifications and various improvements in this useful implement; but I think I have shown enough to prove that the idea was not originally French.

Your obedient Servant,

CHARLES F. T. YOUNG, C.E.

7, Duke-street, Adelphi, W.C., September 20, 1867.

NEGATIVE SLIP.

TO THE EDITOR OF ENGINEERING.

SIR,—I have attentively read the extraordinary production of your correspondent, "C." and, from the first few lines, was misled into expecting that the paradox of negative slip would be brilliantly cleared up (of course to the utter annihilation of Mr. Bourne's ideas on the subject), as he commences by announcing that he can at once find and show us the immediate cause thereof. He is then so kind as to give us some very nearly incomprehensible dimensions of some very improbable screws—one with a pitch of $\frac{1}{4}$ and another of $\frac{1}{2}$ of the diameter—say, of two propellers of 20 ft. diameter each, having pitches of 10 and 15 ft. respectively. What would an engineer say to fitting ships with such propellers? He continues by telling us, as a discovery, that which every engineer knows, i.e., that if a screw be too small for the ship it has to propel, great positive slip is the result, by reason of the small area of impinging surface offered by it. (The foregoing remark is specially intended for "C.'s" information.)

He then says negative slip signifies that the velocity of the screw exceeds that of the ship, thus confusing the positive with the negative, in direct contradiction to that which he says above, and showing a total ignorance of the subject treated upon. But even if he were right, what does the "velocity" of the screw signify? Is it the screw's progression through the water, or is it the velocity of the tips of the blades? If the latter, I imagine it would in any case be considerably more than the speed of the ship. Take, for instance, his 12 ft. screw, with 16 ft. pitch (about the only reasonable one quoted), and drive it at 80 revolutions per minute; this would give 12,619 knots as the speed of the vessel per hour, but the velocity of the tips of the blades would be 29,733 knots.

His showing, or rather asserting, the existence of positive or negative slip in particular cases does nothing towards explaining why negative slip should exist: he merely states what he considers a fact, and leaves us to draw our own inference. If a man of a literary turn of mind went mad, he would probably write nonsense; but the assertion or even proofs of such a proceeding on his part would not show or explain why he did so, or why he became insane.

As to "C.'s" last paragraph, I would only suggest that perhaps he has a few "second-hand" screw propellers which he wants to get rid of; if so, I truly admire his tact and ingenuity, and would recommend any one in the same position to act similarly.

In conclusion, allow me to apologise for the length of my letter, and state that its only object was to prevent any one reading your widely circulated and valuable publication from being misled by the absurdities contained in "C.'s" delightful epistle.

Yours respectfully,

MICHAEL SEPI.

London, September 24, 1867.

TO THE EDITOR OF ENGINEERING.

SIR,—I find that I inadvertently described "negative slip" as implying an actual excess of the velocity of the screw over that of the vessel. I meant to say just the reverse.

Your obedient Servant,

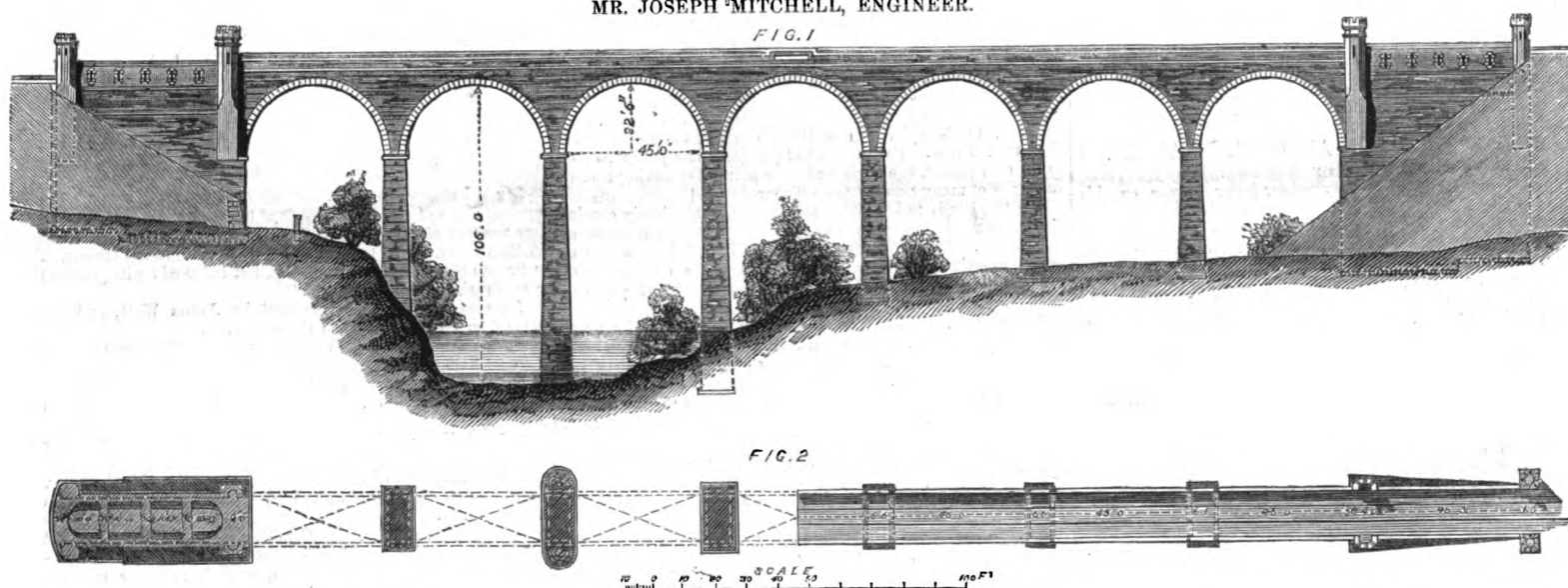
C.

September 23, 1867.

THE FRENCH IRON TRADE.—During the first six months of this year the quantity of iron manufactured in France was 605,082 tons, as compared with 633,958 tons in the corresponding six months of 1866, being a decrease of 28,876 tons. There was also a falling off in the make of pig, the quantity produced in the first half of this year being 429,854 tons, as compared with 454,406 tons in the corresponding half of 1866, being a decrease of 24,552 tons. These figures show that the iron industry of France has suffered equally with this country from the general depression which has prevailed for a considerable time past.

EXAMPLES OF VIADUCTS ON THE HIGHLAND RAILWAY.

MR. JOSEPH MITCHELL, ENGINEER.



THE DIVIE VIADUCT.

We give, on the present and opposite page, some further illustrations representing works on the Highland Railway. We have already alluded in this journal to the great taste and skill with which the architectural portions of these works have been designed; and as the works themselves were fully described in Mr. Mitchell's paper on the Highland Railway, which we published on page 205 of our last number but one, it will be unnecessary that we should add more here.

INDIAN PATENTS.

THE undermentioned specifications of inventions have been filed, during the second half of 1866, under the provisions of Act XV. of 1859, in the office of the Secretary to the Government of India, in the Home Department. Copies have been sent to one of the secretaries to each of the Governments of Bengal, Fort St. George, Bombay, and the North-Western Provinces. A copy of every specification is open, at all reasonable hours, at the office of the Secretary to the Government of India, in the Home Department at the Presidency, to public inspection, upon payment of a fee of one rupee. A certified copy of any specification will be given to any person requiring the same, on payment of the expense of copying.

No. 281. Lieutenant W. J. Carrall, R.E., Assistant Engineer in the Department of Public Works, formerly of Fyzabad, in Oudh, now residing at Roorkee, for a new mode of equalising or regulating the discharge of water from orifices under varying heads.

No. 289. Mr. Henry Gartner, No. 4, Dalhousie-square, Calcutta, chronometer, watchmaker, and jeweller, for a self-acting punkah.

No. 292. Mr. Walter Raleigh Gilbert Hickey, C.E., Calcutta, for improvements in railway sleepers.

No. 295. Mr. William Riddle, C.E., of Church Gate-street, and Mr. Alexander Charles Brice, of Colaba, both in Bombay, for improvements in apparatus for compressing cotton or other material.

No. 296. Mr. Digby Murray, master mariner, of Dundee, in Scotland, for a block for lowering boats from steamers or sailing vessels while the said steamers or sailing vessels are in motion.

No. 298. Mr. A. W. Campbell, merchant's assistant, residing at Middle Colaba, in the Island of Bombay, for compressing cotton, wool, or other substances of a fibrous nature.

No. 299. Mr. R. Newton, M.E., No. 7, Hummam-street, Bombay, and Mr. J. Sykes, cotton mill-manager, of Coarlar, near Bombay, for an improved arrangement of presses and machinery for the purpose of either half or fully pressing cotton, wool, or other fibrous substances.

No. 300. Mr. F. J. V. Minchin, of Aska, Madras Presidency, for an improved process for extracting the juice from sugar-cane, beet-root, and other plants.

No. 302. Mr. J. Gale, junior, of Devonshire-terrace, Plymouth, England, electrician, for improvements in preparing and treating gunpowder.

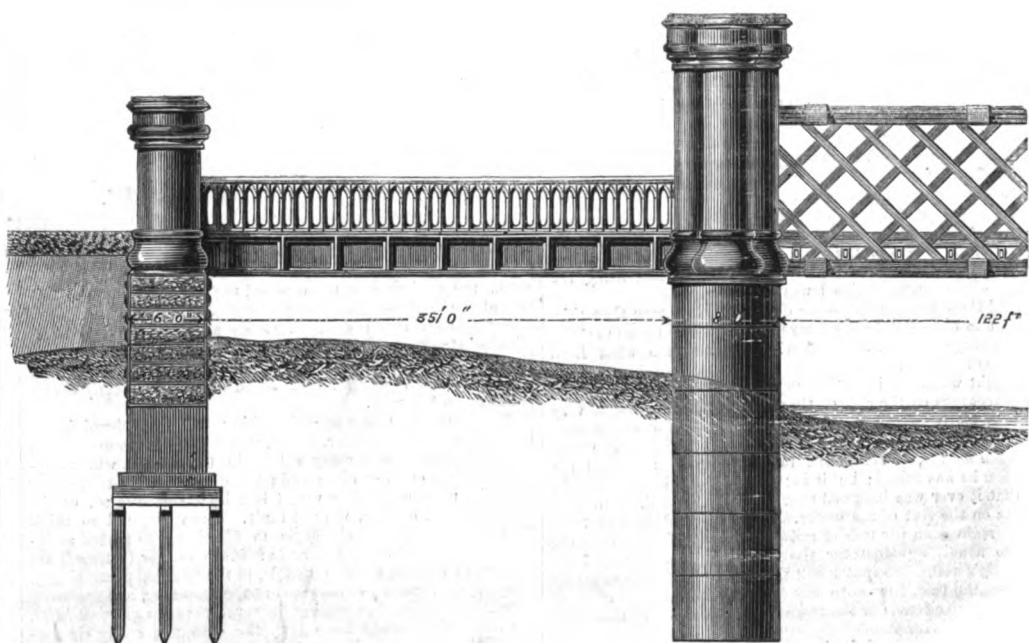
No. 303. Mr. James Templeton Wood, of Inner Temple, London, barrister-at-law, for improvements in the means of, and apparatus for, compressing and packing cotton, wool, jute, and other similar bulky articles.

No. 304. Captain Cowper Phipps Coles, R.N., of Ventnor, in the Isle of Wight, for improvements in protecting the bottoms and sides of ships and other structures exposed to the action of the water.

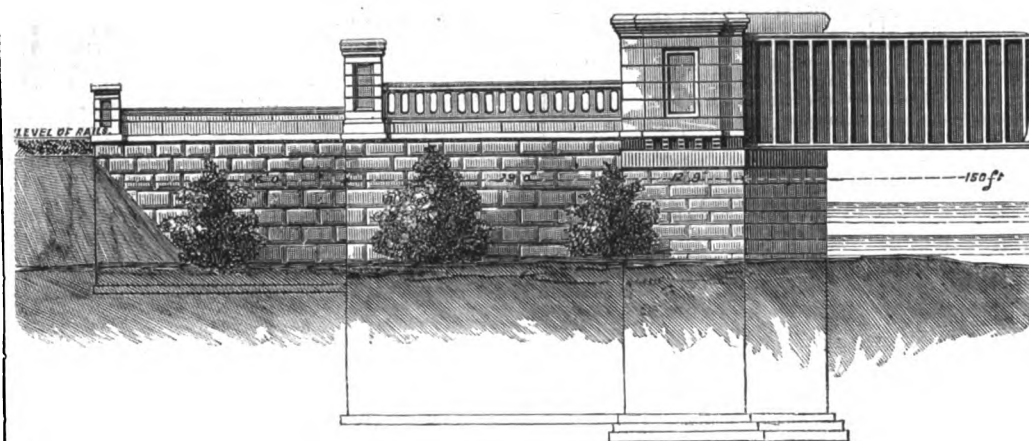
No. 306. Mr. F. Saintyves, artiste-mécanicien, No. 61, Cossitollah, for punkah pulling-machines.

No. 307. Mr. Eugène Pierre Barrabé, of Paris, for improvements in apparatus applicable to the clearing and decortication of corn and grains of all kinds.

No. 308. Mr. John Kay Farnworth, of Alderly Edge, in the county of Chester, for improvements in apparatus for



ABUTMENT OF THE TUMELL VIADUCT.



ABUTMENT OF THE FINDHORN VIADUCT.

raising and lowering the windows of railway and other carriages, and other windows.

No. 309. Mr. Charles Thieme Liernur, of Frankfort-on-the-Maine, in Germany, for a pneumatic method for the in-offensive removal of all fluids, solids, and gases from water-closets or privies, and other conduits, and of storing said materials so that they may be applied in their natural unchanged form to agriculture and other branches of industry.

No. 311. Mr. William Boyd Livingstone, Officiating Assistant-Professor of English Literature in the Presidency College, and of No. 13, Sudder-street, Calcutta, for using cotton in certain peculiar ways for all the purposes for which blotting-paper is now used.

No. 312. Mr. William Boyd Livingstone, of No. 13,

Sudder-street, Calcutta, for punkah-pulling and thermautidote-machine.

No. 313. Mr. William Boyd Livingstone, of No. 13, Sudder-street, Calcutta, for an irrigating and motive-power machine.

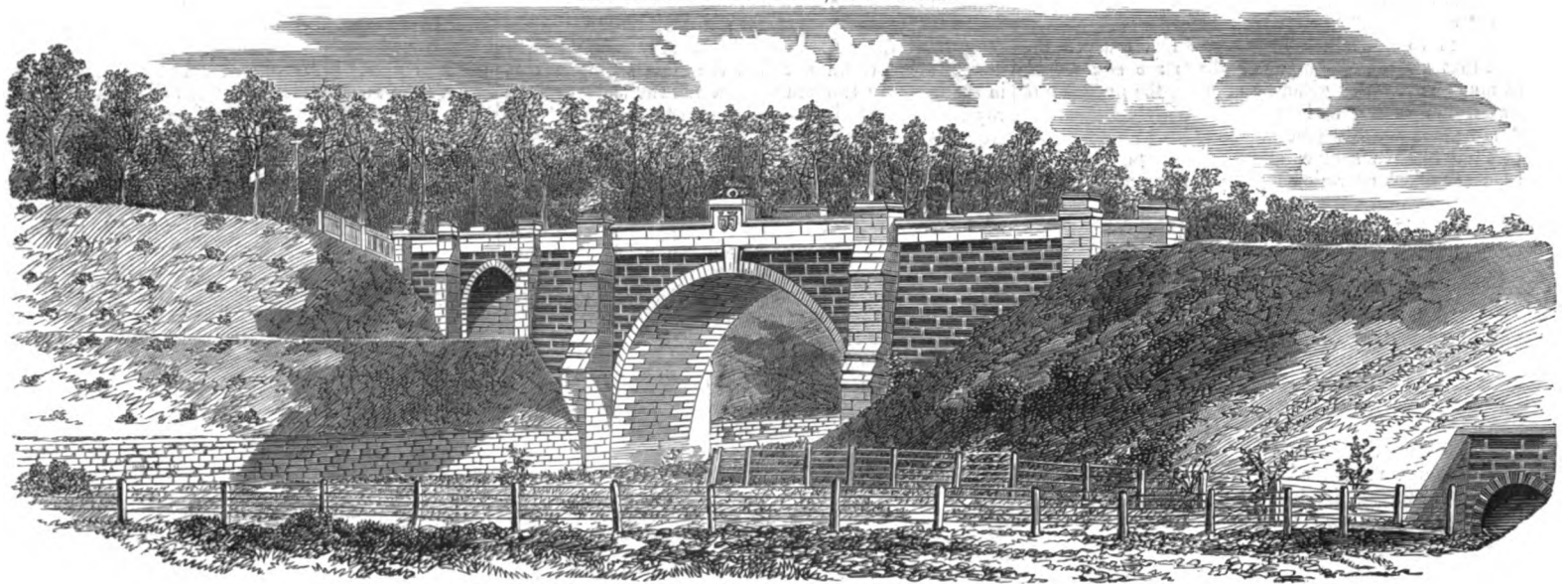
No. 314. Mr. Henry Clifton, of London, for an improved churn.

No. 316. Captain Francis John Bolton, of No. 13, Bruton-street, London, for improvements in the mode of transmitting messages by the electric or magnetic telegraph.

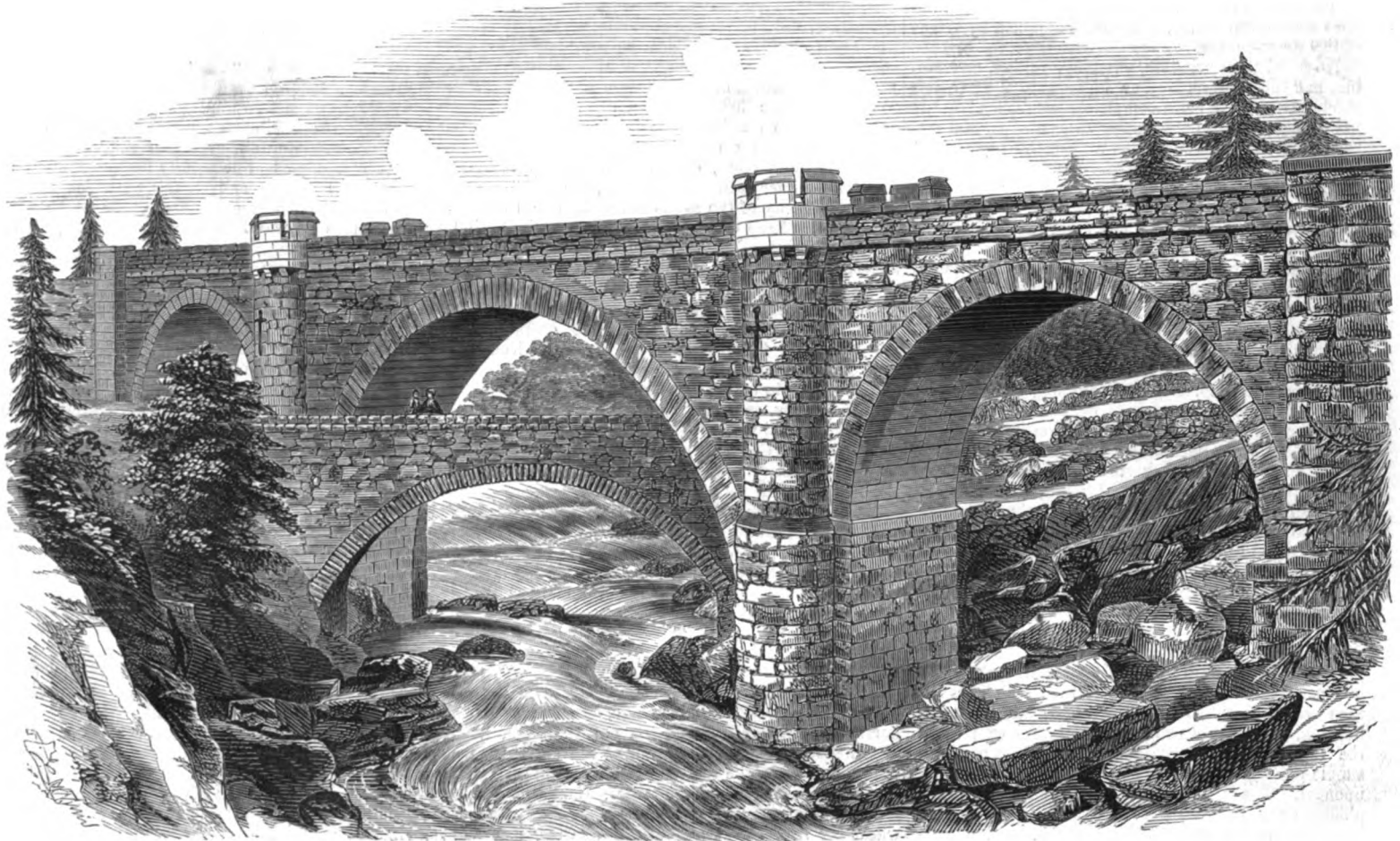
No. 317. Mr. F. Saintyves, artiste-mécanicien, No. 16, Cossitollah, and Mr. P. W. Fleury, No. 17, Joratallao-street, for improvements in the motive power of F. Saintyves's punkah pulling-machines.

EXAMPLES OF BRIDGES AND VIADUCTS ON THE HIGHLAND RAILWAY.

MR. JOSEPH MITCHELL, ENGINEER.



PARKHILL BRIDGE.



SALVINE VIADUCT, STRUAN.



ALNESS BRIDGE.

STEAM-CULTIVATION.

DR. JOHNSON and his followers had Latinised the good old Saxon *till*, *tillage*, and *tith* into "cultivate" and "cultivation" generations before—with all the readiness to adopt new terms—we had grasped the idea that all the operations of tillage are *mechanical*, as much so as the grinding of corn, the pumping of water, the rolling of iron, or the weaving of cloth. A few years ago it would have only led to a confusion of ideas to have spoken even of reaping or thrashing as mechanical operations. The scholar would have shown that they were manual only, and that neither the sickle nor the flail was a true *μηχανή*, since it was not employed "to augment or to regulate force or motion," nor was it "a complex structure, consisting of a combination or peculiar modification of the 'mechanical powers.'" The same might have been said of a sewing-needle, of a sail or an oar, a wain or a pack saddle, and yet the operations of reaping, of thrashing, of sewing, the impelling of vessels through the water, and the transport of burdens upon land, are now recognised as purely mechanical forms of work. Even writing, painting, sculpture, and music involve much mechanical action in their execution; and if, dismissing the idea of originality implied by each of these arts, we content ourselves with the mere reproduction of the works which they comprise, we may have mechanical writing, mechanical painting, mechanical sculpture, and mechanical music. Indeed, all motion, of whatsoever kind, comes within the range of mechanical science, and as all material motion implies mechanical power, this can be supplied by means of the steam-engine.

No problem in grinding, pumping, rolling, or weaving, in locomotion on land or the propulsion of vessels through water, is more completely mechanical in its nature than that of the breaking up, inversion, and thorough loosening of the soil, as understood by the term tillage, or cultivation. Whether the power be applied through the human arm and a spade, or through a horse-drawn or bullock-drawn plough, or through a steam-drawn implement of any kind, the operation is equally a mechanical one, being the application of destructive and disruptive forces to overcome the cohesion and inertia of the soil. As for its inertia, the weight of loose earth, a foot deep, over an acre of land, is no less than 1500 tons. Even in moderately light ploughing the draught of a pair of horses is about 3 cwt., and in cutting a furrow 9 in. wide 3712 foot-tons of work are thus expended in ploughing an acre. In other words, as much work is done as if a weight of 1 ton were lifted a mile and five furlongs high in the air, or if a 25 ton locomotive were lifted to the top of St. Paul's. The work, thus considered, appears large; but the horses walk 11 miles, and occupy at least half a day in doing it. The force thus expended upon the land is applied in the simplest manner known to mechanical science, to wit, by pulling in a straight line; not but that the implement might be pushed with equal effect, but in this case the application of the pushing power would be obviously inconvenient and disadvantageous.

The purely mechanical nature of the problem presented by all forms of cultivation, where the implement is drawn through or over the ground, is more than ever apparent when we thus regard all the cutting, pushing, and otherwise disturbing forces exerted by the implement as proceeding from the single and simple pulling or tensile force acting in a right line upon it. The forces and motions imparted by a plough or a cultivator to the soil itself may be numerous and somewhat complicated, and it has indeed taken a long time to arrive at those forms of ploughs and cultivators which act best upon the soil with the least draught, or, in other words, with the least mechanical power. But, having once settled upon the form of plough or other implement to be used, all ploughing and all cultivating by whatever kinds of implements become merely a matter of *pulling*, as much so as pulling a railway train, or pulling coals out of a pit, or pulling round and round the wheels of a factory by means of driving-straps or the teeth of the spur-gearing. Steering may be still required, but this is a simple and an easy matter, as it is in the case of steam-vessels driven with thousands of effective horse power, and yet obedient to the guidance of one or two men at the wheel.

When the whole work of tillage, or cultivation, is reduced to the simple mechanical idea of *pulling*, the case of steam as against horse-power is already made out. Steam can always pull more cheaply than horses. This might be proved even of the street traffic of London, but there are certain objections to the presence of steam-engines in the streets which we need not discuss.

It is sufficient that there are no substantial objections to steam upon the farm, and many thousands of farm engines are already in use, although but a few hundreds of these are as yet used for ploughing. There is no doubt that many farmers have reasoned to themselves that, where the pull is no more than that of a pair of horses, steam could not show the same advantages as in the immense traction upon a railway train or a pit rope, and that the interest on the cost of an engine and steam tackle, and the cost of feeding and working it, and keeping it in repair, would, after all, exceed the total cost of horse work. But the great value of steam-cultivation comes from the fact that from three to ten times the draught of a pair of horses may be effectively applied by it, in breaking up and stirring the soil, and that, too, at twice the speed of horse-pulling. While the pair of horses are getting over their one acre a day, the steam plough will do from ten to fifteen, and that to a greater depth, and with more effect in knocking the ground completely to pieces, which is the object of all ploughing and cultivating. And this is done without any treading of the ground, whether before or after the implement has gone through it—a treading which, in the case of a pair of horses, leaves more than 200,000 foot-prints per acre when cutting a 9 in. furrow—a treading which, for so much of it as is upon the yet unploughed ground, is known to add about one-third to the draught of the plough, while that of the off horse, at the bottom of the furrow, by so much undoes what the plough has already done, forming a hard pan, which, in its turn, ought properly to be ploughed again.

So long, indeed, as we continue to employ horse-pulling in tillage, so long must we have imperfect and insufficient tillage—so long indeed must we remain practically ignorant of what thorough tillage really is. We are in the habit of measuring the productive capacity of the arable land of England as if it were almost of necessity a fixed quantity, capable of no considerable increase, except of course by bringing fresh land under cultivation. Now, the present productive capacity of the soil is that only due to horse-tillage, or, to keep the mechanical idea clearly in mind, to horse-pulling. Yet the farmer knows quite well that, if he chooses to expend sufficient labour with a spade, he can, by turning up and loosening retentive ground two or three feet in depth, greatly increase its crop-growing power, giving to a fair ordinary soil the fertility of the richest wheat lands in Kent, or that of the famous Carse of Gowrie, in Scotland. If it were possible to carry on spade husbandry as rapidly and as cheaply as ordinary tillage, there can be no question that all the arable land in the kingdom would be spaded, nor that the crops taken off, if not doubled, would be very largely increased. In thoroughly knocking the soil to pieces, the steam plough, the steam digger, the steam cultivator, and the steam harrow, by reason of the great power and high speed at which they are worked, approach the effectiveness of spade tillage, and the committees of the Royal Agricultural Society on steam-cultivation have found evidence that steam-tilled land has given, in some cases, two quarters of corn more per acre than like land tilled by horses. So far from this being a statement to be suspected of exaggeration (it is, however, well authenticated), it really expresses but the matter-of-course result of thorough tillage, as contrasted with horse tillage, which commonly is not thorough, however mellow the land may appear at the surface. No farmer requires to be told that the best tilth gives the best crops. In the proved cases, therefore, where steam tillage has given an additional two quarters of wheat per acre, and worth 60s. a quarter, it would require but the increased crop on 200 acres, in a single year, to pay for a double engine tackle of the first class, or, in other words, it would return 1200% additional from but 200 acres of wheat.

Limited, as British agriculture has heretofore been, by the partial and imperfect character of horse-tillage, or, in other words, by the necessity of employing a costly and relatively weak form of mechanical power, we are yet ignorant of what the soil is really capable. From the want of steam power, which alone can properly deal with such work, under-draining has not been carried on to anything approaching the extent required for good tillage. When our stiff heavy soils shall have been drained and thoroughly broken up, so that the whole of their chemical constituents are accessible to the roots of growing plants, the crop will inevitably be greater, and probably very much greater, than now. It will be, in effect, spade-husbandry, only other implements and other forces than spades and the forces of men's muscles will be brought to bear. It is more than likely, when all tillage is everywhere understood as merely a matter of *pulling*, and that pulling

by steam is always cheaper and better than pulling by horses, that horse-drawn implements of all kinds will come to be regarded in common with the road wagons and mail coaches and sailing packets of old—with windmills, horse-mills, the reaping-hook, and the flail.

It is singular that while steam has been so long applied to nearly every other form of mechanical work, it has been applied only so lately and so slowly to the most important of all forms of mechanical work, that of tillage; and what is a farm but a great laboratory and a manufactory of food? Many difficulties have stood in the way, but the real and greatest difficulty of all has been the unbelief, on the part of farmers, that steam could be applied with real practical advantage to tillage. Even now, after all that has been done, there are not probably four hundred sets of steam tackle in the kingdom. Yet it is a hopeful sign that the number is now being increased at a brisk rate, with every prospect of ultimately reaching a point corresponding to one set of tackle for every 2000 acres of arable land in England and Scotland, if not in Ireland. There have, no doubt, been those who were willing to believe, in the abstract or in theory, that steam-cultivation was practicable, and that it *ought* to have an advantage over horse work, but these half-believers were not prepared to make the experiment for themselves. Others have been restrained by the want of capital. Much has been accomplished, however, by the steam-plough companies, like those at Hereford, Whitechurch, Wellesbourne, Wakefield, the North Staffordshire company, &c., who take the whole risk, and let out their engines and tackle, sending their own men, to work for whoever likes thorough cultivation at a moderate price. In this way, and in the hands of private owners who "let out" engines and ploughing tackle, steam tillage has not only now gained a fine start, but a new and profitable investment is afforded for the capitalist. Several new steam-ploughing companies are now projected, and it is probable that their number will be greatly increased when once the business talent and energy to which we have been accustomed in railway and other public undertakings finds its way into this new channel. To the young pushing engineer, knowing something of men and of business, perhaps no opening, just now, is more promising than that which is afforded by the opportunity of promoting and working steam-plough companies. Alas! we fear that those who already consider themselves engineers know too little of the field and of farming for this. But the right kind of talent is being slowly supplied from among the farmers themselves, and already we have a number of well-known and undeniably clever agricultural engineers, makers of traction and portable engines, and managers of steam-plough factories and of steam-ploughing companies, who, a few years ago, were plain farmers. Some of these, as is well known, are men of ingenuity and abundant mechanical resources, and who, in their works, show excellent mechanical judgment.

It is not to be denied, however, that very considerable mechanical difficulties required to be overcome before steam pulling could be successfully applied to tillage. Steam-farming, indeed, presents more natural difficulties than perhaps any other problem in the whole range of mechanical engineering. The engine cannot work upon fixed foundations like a factory engine, nor upon evenly laid and uniformly gauged rails like a locomotive, unless of course Mr. Halkett's once-famous proposition of guide-way agriculture were reduced to practice. An ordinary portable engine, if of sufficient power to work ploughs in heavy soils, would weigh six or eight tons, and the movement of such an engine by horses is often a difficult matter, as the ground over which an engine must be taken is often impassable, or nearly so, to horses. Portable engines have been applied, however, and with fair success, to the tillage of land of moderate stiffness; but the requirements of steam tillage in its widest application point clearly to the necessity of self-moving or locomotive engines. There are obviously, two modes in which such engines may be employed. One is that where they travel to-and-fro over the land, dragging the implement behind them. Romaine's rotary digger, which attracted much attention a few years ago, was worked in this way, being indeed part and parcel of the engine itself. There are in all cases serious objections, however, to locomotives moving up and down the field for each breadth of ground ploughed or cultivated, and upon wet and greasy soils their use would be impracticable. In the first place, they consume a good proportion of their own power in moving themselves about, and the incessant jolting tells upon their structure, and involves an increased outlay for repairs. To take a 4 ft. breadth, the engine would require to travel rather more than two miles

for every acre cultivated, and supposing its draught to be, say, 30 cwt. on firm ground on a level, and its weight 9 tons, the whole of this draught would be absorbed in overcoming the mere gravity of the engine itself on an incline of 1 in 6, leaving nothing for the implements. Again the engine, weighing, say, 9 tons, would act as a steam road-roller upon the ground, and even if it were kept off the ploughed portions, the pressure of its wheels would so indurate the soil in front of the plough, or cultivator, as to add very materially to the resistances which either of those implements would have to overcome. As for harrowing and cross-harrowing an already cultivated field by means of an implement drawn direct by a 9 ton locomotive, any farmer will understand that the engine would do more harm than the harrow could possibly do good. The locomotive engine, drawing the implement, would lose much time in turning at headlands, and could not work so close up as an implement worked by other means.

The only other mode of working the implement is that of drawing it to and fro, by means of chains or ropes, by an engine or engines fixed at a corner or the sides of the field. Here the objections to the locomotive engine, working up and down the field, and dragging the implement directly behind it, are avoided, and the question is reduced to one of the transmission of power. This mode of working implements was proposed and patented by a sanguine inventor, one John Tulloh Osborn, more than twenty years ago. But he proposed to drag the plough or cultivator by means of chains, and although an inventor, in the early stages of a great invention, commonly has a faith which should move mountains, we will venture the opinion that Mr. Osborn himself, if he be now alive, will agree that chain-traction is an impracticability. And if he does not, any of our agricultural engineers could assure him, in all sincerity, that it is so. Going from chains to ropes, we need not say that a hemp rope, under a draught of 20 cwt. or 30 cwt., and dragging over broken or stony ground, would stand a poor chance in the field. It is beyond dispute that steam-ploughing owes almost everything to the invention and successful manufacture of wire rope. The steel rope of 1867 is, indeed, one of the marvels of the present century, not merely because of its wide usefulness, but for its wonderful strength, hardness, and pliability. The late Mr. John Fowler, when bringing out his first steam-plough, adopted wire rope, as, indeed, there was nothing else which would have answered the purpose. But wire for ropes was then made only of iron, and the ropes were not remarkably strong, although stronger than hemp; they bent readily, and were, of course, injured by bending; they were especially given to rusting, and they chafed rapidly whenever they were allowed to drag upon the ground. The iron of which they were made had a tensile strength, when in the bar, of less than 30 tons per square inch; in other words, a weight or dead pull of 30 tons would pull in two a bar 1 inch square. Drawn into wire, the tensile strength was increased to probably 45 tons for an actual section of wire equal to 1 inch square. Attempts were made later to draw good tough steel wire, but this was found to be brittle, although strong at a dead pull. But, by degrees, steel, not only of enormous strength, but of great pliability, has been obtained, and this is now used for pulling steam ploughs and cultivators. The mode of making this wire is still a secret, but there is no doubt as to its qualities when made. For steam-ploughing a rope of 24 steel wires of No. 14 gauge is now used. No. 14 gauge is about $\frac{1}{16}$ th in., or exactly .085 in., in diameter, and it requires 176 such wires to form a total section of one square inch. Their weight is but an ounce to the yard, and when laid in a rope, in which considerably more than a yard of each wire is required for a yard of rope, the weight is hardly 2 lb. per yard, or less than a ton for a thousand yards. Yet each of these slender wires will bear a pull of from 2000 lb. to 1 ton, equal to a tensile strength of from 160 to 175 tons per square inch of metal, a strength never before attained with any other material known to man. Every wire used in the best steam-ploughing ropes is tested, and we have witnessed many of these tests, showing a remarkable uniformity in the results. Each wire is exceedingly stiff; it is nearly impossible to bend it in the fingers, and yet when sufficient force is applied it may be twisted around an iron rod not larger than a pipe-stem without breaking. Ropes made of such wire are at once strong, hard, and pliable. It is impossible to break them in fair work; they wind perfectly upon the coiling drums without injury, they will bear considerable dragging upon the ground without chafing, and they rust but little. A single rope now serves for working over from 2000 to

4000 acres, the amount varying with the nature of the soil and the breadth of implement used, and the highest estimate of its wear and tear is about 10d. per acre. As to chafing, some farmers even prefer to allow the rope to drag upon the ground, except upon gravelly soil, finding, as they assert, that the wear, whatever it is, costs less than the wages of boys to attend to the rope-porters commonly employed. This dragging is attended however with much friction and a loss of power.

With a portable engine, or rather a self-moving engine, and with steel ropes such as we have described, a hasty observer might conclude that the whole problem of steam-ploughing was solved. So far from this, it has required, on the part of the late Mr. John Fowler and his assistants, such an amount of ingenuity and perseverance to perfect this remarkable invention, as is only to be matched in the history of the locomotive engine, or in that of some of the more complex and beautiful examples of spinning and weaving machinery. The transmission of the power from the engine to the implement was a nice problem, and new implements indeed required to be invented. With steam power equal to that of from twenty to thirty horses (for the nominal power at which engines are rated as "10 horse," "12 horse," &c., bears little relation to their real power), an implement taking a breadth three or four times greater than that of the old single-furrow plough was admissible and was indeed required, and as such an implement would necessarily be of considerable weight, it was desirable that it should not require to be turned at the headlands, but be capable of working to-and-fro in either direction. There were schemes long ago, and Fiskin's was one, for mounting two sets of ploughs in a frame, one set pointing in one and the other in the opposite direction, and these ploughs were so contrived that either set could be raised and lowered at the will of the ploughman. One set was "right hand," and the other "left," both turning their furrow the same way. Thus while one set was in the ground, and at work, the other, pointing in the opposite direction, was clear of the ground, and ready to be lowered, in its turn, at the next headland, the means employed for lowering either set of ploughs acting to raise the other set. Fowler's balance plough was an improvement upon this idea. It consists of a double-ended iron framing, each end mounted with ploughs pointing towards those on the opposite end, the whole tipping readily upon a pair of wheels. It is shown in Figure 6, page 301, and will be recognised in several of the other figures. The same arrangement is employed also for the steam-cultivator, the opposite ends of the tipping-frame being mounted with sets of cultivating tines. As every ploughman knows, it is much easier to take a furrow along the edge of one already turned, cutting away the soil from the side, than to open out a cut through solid ground. The several sets of shares or cultivating tines in the balance-plough or balance-cultivator are set, therefore, one behind another, so that the second share from the front cuts from the side of the first furrow, the third share cuts from the side of the second, and the fourth from that of the third. In this way no single share or tine is working down into solid ground, except, of course, the front share or tine when cutting the first furrow in a field. The number of furrows is governed by the nature of the soil and the amount of power at command. Messrs. John Fowler and Co. have made a few steam ploughs to cut six furrows at once, and one, sold some time ago to a French farmer, who is working it near Paris, has eight moulds and shares at each end of the tipping-frame. It will be seen in the drawings that the wheels upon which the plough-frame is balanced are of unequal diameter, and the reason will be at once understood when it is considered that one runs along a road the whole depth of the furrow below that of the other. The wheels of course are loose on their axes, and the inequality of diameter does not tend therefore in any way to turn the plough out of its course.

We are not describing the separate features of the complete system of steam-cultivation in the precise order in which they were invented, but rather in the order in which one new to the whole subject might have taken it up, first in its general aspects, and afterwards in its details. So far we have the general ideas of steam-cultivation, the self-moving steam-engine giving off its power to the implement through a wire rope; and of the implement itself, a ploughing-machine, working in either direction, and turning its four, six, or even eight furrows all the same way in whichever direction it may be going. The nicer details, upon which everything depends, and which have been so admirably worked out, strike the attention with equal

force when once they are carefully examined. The point to which the steam-ploughing engineer had to direct his best ingenuity and judgment was that of the transmission of the steam power, through the wire rope, to the implement in any part of the field. To pull the implement towards the engine was easy enough; but it was equally necessary to pull it away from the engine, when but a single engine was employed. It was necessary also to shift the implement into fresh ground at the end of each bout. To pull the implement away from the engine, was practicable when the rope was led around the boundaries of the field, its direction being maintained by means of sheave pulleys anchored at the corners. The opposite ends of the rope were attached to the implement, and the rope itself was then alternately driven in opposite directions by means of winding-drums upon a separate framing, and driven by the engine. To plough a square field of 20 acres upon this plan, at one setting down, would require at least 1555 yards of rope, the field being 311 yards square. At each bout of the implement two of the sheave pulleys would have to be taken up and re-anchored. This, "the roundabout" system, was generally adopted in steam-ploughing in the earlier stages of the invention; but it has now, to a great extent, been superseded by more direct and effective arrangements. Even upon this plan, however, as upon all the others, the implement is driven at $3\frac{1}{2}$ miles an hour in ordinary soils; and this, when taking a breadth of 4 ft., and allowing one-tenth of the time to be lost at the headlands, is equal to nearly $1\frac{1}{2}$ acres per hour.

A more direct plan of working is that with an engine travelling intermittently, as each breadth is completed, along one headland. A pulley is secured to an anchor capable of being moved at corresponding intervals along the opposite headland. The rope passes around the winding-drum on the engine and around the distant pulley, and being secured to the plough, the latter is drawn to and fro between them. A still better plan, now largely adopted, is that of employing two engines, one at each headland, and drawing the implement alternately by each. In this case, however, each engine is standing for half the time.

A further improvement lately introduced by both Messrs. John Fowler and Co., of Leeds, and by Messrs. J. and F. Howard, of Bedford, is that of drawing two implements in opposite directions between a pair of engines, which are then both worked continuously, except for the momentary stoppage in reversing.

Our illustrations on page 293 show all these systems, except the original "roundabout" plan.

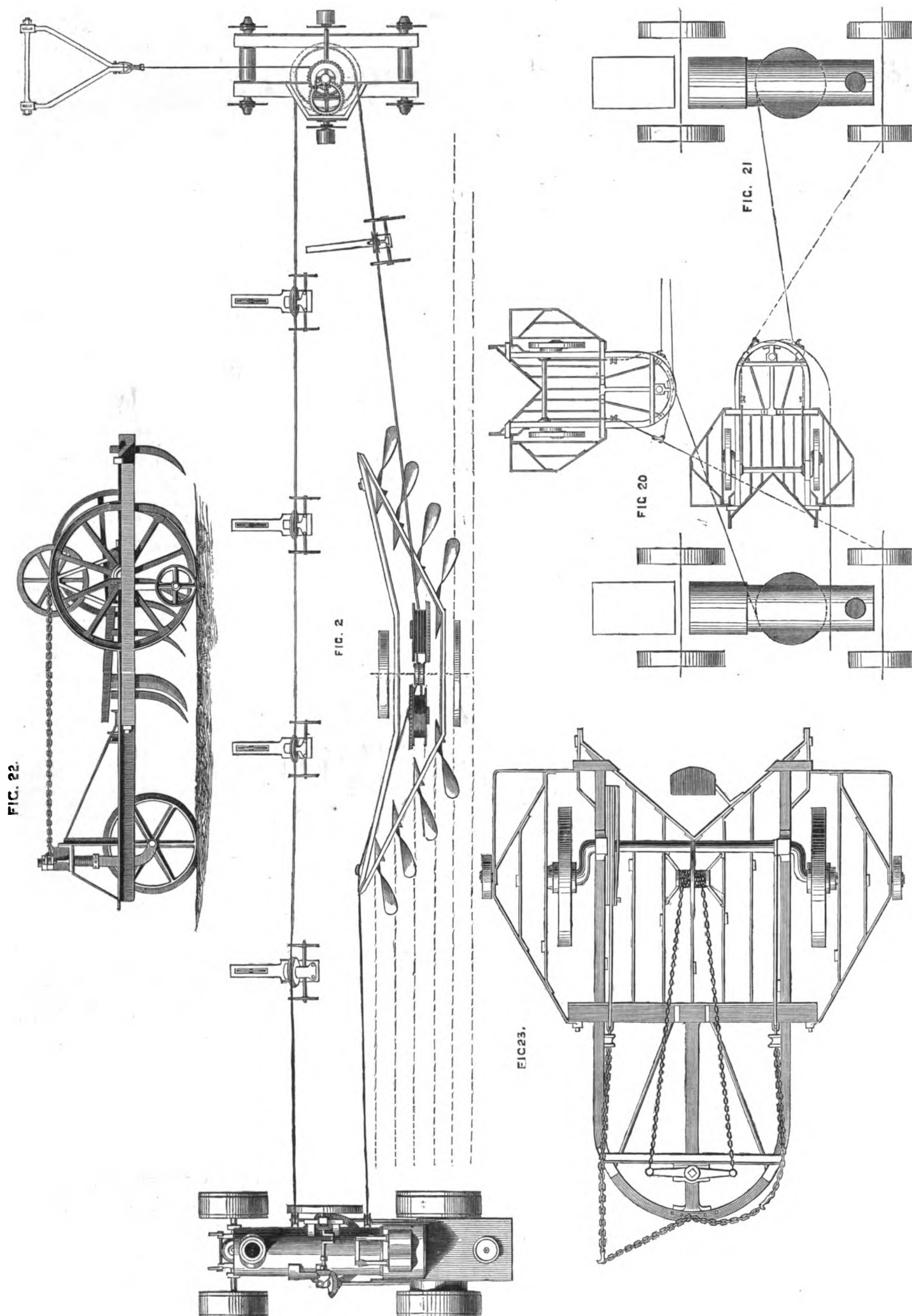
These various arrangements of the engines, implement, and rope are readily understood; but it is an important matter also to wind the rope in uniform layers upon the coiling drum (where a coiling drum is used), and also to adjust the length of rope out to the varying width of the field, where this does not happen to have exactly parallel sides. It is important, too, where coiling drums are used, that the one which is paying off the rope shall let it out under a certain tension, sufficient to prevent it from fouling its own coils, one upon another. All these are matters of nice detail, upon which the success of steam tillage has been greatly built up, and yet they are hardly matters which would occur at all to a general observer, nor can their importance be fully appreciated, except by the mechanical engineer. The engineer will understand, too, that it must be desirable to get rid of coiling drums altogether, and to employ an endless rope, working like a driving-strap around a pair of pulleys. This result has been attained by the elegant device of the "clip-drum," which will be described in the course of the present article.

In Messrs. Fowler's ploughing-engines the rope-drum revolves in a horizontal plane, upon a vertical axis beneath the boiler. Special coiling gear is provided, therefore, to prevent the rope from dropping down while being wound upon the drum. The height or vertical width of the drum corresponds to about ten thicknesses of the rope, coiled side by side, and it was a neat problem in mechanics to contrive an apparatus for laying the rope uniformly upon the drum. It was only necessary to cause a pair of small guide-sheaves to traverse uniformly both up and down the face of the drum, once for every twenty revolutions which it made. This was effected in the manner shown in Fig. 16, page 301. Centred upon and revolving with the winding drum is a pinion, I, and beneath it is a pinion, H, turning loosely upon the spindle, and having one tooth less than I. Another pinion, J, placed to one side, and carried around bodily by the winding drum, in which its own centre is fixed, and having a width equal to that of both pinions, I and H, gears into both, and

(Continued on page 294.)

STEAM PLOUGHING APPARATUS.

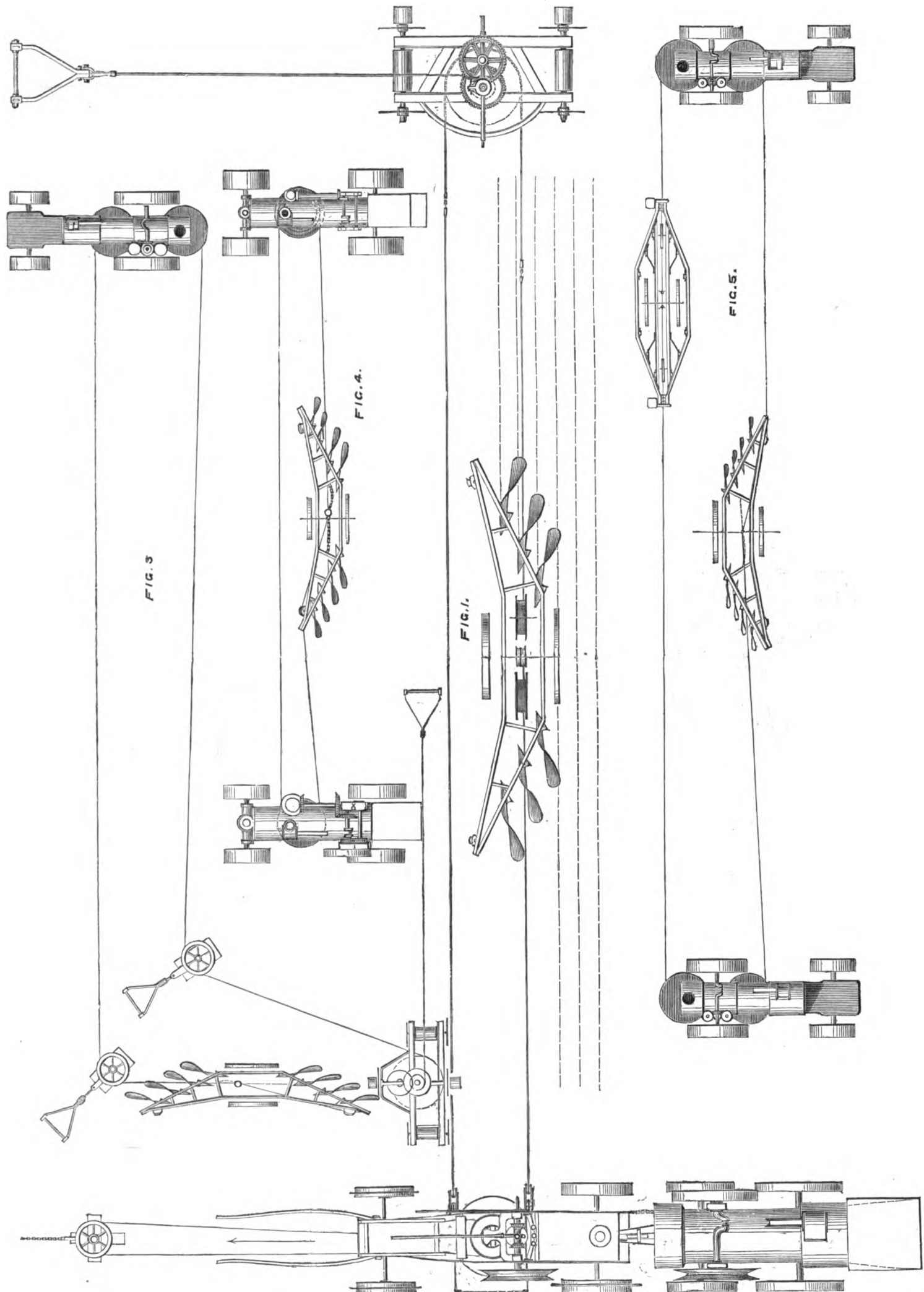
MESSRS. JOHN FOWLER AND CO., ENGINEERS, LEEDS.

(For Description, see Page 290.)

STEAM PLOUGHING APPARATUS.

MESSRS. JOHN FOWLER AND CO., ENGINEERS, LEEDS.

(For Description, see Page 290.)



RANSOME'S PATENT STONE.

(From the Bombay Builder).

We are enabled, through the courtesy of Government, to place before our readers Captain Ducat's official report on the experiments made by him in the beginning of the year in making Ransome's patent stone; as also the report of the Chemical Analyst to Government on the same.

Our own observations on the specimens we were favoured with go to confirm Dr. Lyon's analysis. These specimens become extremely hygrometrical during wet weather, a condition due doubtless to the presence of saline in the sea sand used, which no number of washings will effectually remove.

Captain Ducat will, we believe, continue these experiments with river sand obtained from a good way inland; but, in justice to the inventor, and equally to our Indian experimenter, Government should obtain from Mr. Ransome a fresh supply of the materials necessary; those with which the experiments have been carried on have been for some years knocking about the store yards in Bombay, and have doubtless become much deteriorated:

"No. 188 of 1867.—PUBLIC WORKS DEPARTMENT,
Bombay, 26th March, 1867.

"To the Chief Engineer, Presidency Division, Bombay.
"Sir,—I have the honour to inform you that, in accordance with the instructions conveyed in Government Resolution No. 4573.E. of 1866, of 17th December, 1866, I have conducted some experiments in making stone by Ransome's patent process, some of the results of which I now submit for the inspection of Government.

"I received the Government resolution above referred to on the 21st December, 1866, and as soon after this date as possible I moved some of the chloride of calcium and silicate of soda from the store-yard of the Executive Engineer Presidency, into my own workshops, brought over and set up the mill for mixing the material, which was sent out by Mr. Ransome (without which I found by experience that I could not mix the material properly), and commenced my experiments.

"I have now made five complete experiments; but that Government may not think I have been unnecessarily tardy in carrying out their wishes in this matter, I must state that each experiment absolutely occupies from ten to fifteen days, and nothing could be done towards making a fresh attempt until the success or failure of the preceding one had been ascertained.

"Of the five attempts I have made, the first two were utter failures; the other three, however, may, I think, be looked upon as successful, at least as far as the quality of the stone is concerned. The castings are not as good as they might be; but this is owing, in a great measure, to the mould, which is an old plaster of paris mould, having been used in all Captain Fuller's experiments, as well as mine now, and being in consequence a good deal worn and injured in parts. The attempt I have made in colour is also not quite satisfactory, being too deep a red; but in these minor points I hope to be more successful when I next report on this subject to Government.

"I have ordered a mould for a full-sized capital for a 10 in. shaft, and when this is ready, I hope to make some more presentable specimens of stone, and to give the crushing strength of it also.

"I should have delayed this report till I could call it more complete than it is at present, had it not been that Government Resolution No. 4573.E. of 1867 informs that the Secretary of State for India has called for the results of these experiments; and as these specimens now put before Government, which are certainly harder than most natural sand-stones, show clearly that, with proper care and management, stone can be made in India as elsewhere by Ransome's patent process, I have thought it right to send in this first report.

"In my second report I propose entering more fully into the subject of cost of construction, &c.; but I can here state that the best, because the last made specimen now submitted, is composed of common sea-sand (washed) from Worlee, and white clay from Bunder Wara Hill, in Mazagon, of which there is any quantity about here; that the manipulation, when once understood, is neither difficult nor expensive, and that the results are quite certain and free from any risk of failure.

"I send specimens of my three successful experiments.
"The first, marked number six, is composed of 6 parts sand and 1 part chalk, mixed in Ransome's mill for ten minutes, with 1 gallon of silicate of soda to each cubic foot. At the end of the ten minutes' mixing it was taken out, moulded, and put into a cold solution of chloride of calcium, and when the solution of calcium had thoroughly penetrated the mass, the temperature was raised almost to boiling point.

"The second specimen, marked No. 7, consists of 5 parts sand, 1 part brickdust, and 1 part chalk, mixed with one gallon of silicate to the cubic foot for fifteen minutes, moulded, and put into cold solution of calcium for forty hours, and then boiled for four hours. These stones took three days' washing in running water before all salt was removed.

"No. 8.—The best specimen I have is composed of 6 parts of sand to 2 parts white clay or moorum. This was mixed in mill for ten minutes, moulded, and immersed in cold calcium for forty hours, and boiled for four hours and allowed gradually to cool. Washed for seventy-two hours in running water and dried.

"No. 9 is treated exactly the same as No. 8, but differs from it in the proportion of sand and clay, being composed of 6 parts sand and $\frac{1}{2}$ part white clay. It is a coarser stone than No. 8, and, being very gritty and stiff, is hard to mould into form.—I have the honour, &c.,

(Signed) "W. M. DUCAT, Lieut. R.E.,
Executive Engineer for Reclamations."

"No. 68 of 1867.—OFFICE OF THE CHEMICAL ANALYSER,
Bombay, June 8th, 1867.

"To the Secretary to Government, Public Works Department, Bombay.

"Sir,—I have the honour to acknowledge receipt of resolution of Government, Public Works Department, No. 169E—

830 of 1867, forwarding certain specimens of artificial stone, manufactured by Ransome's process, for opinion and report.

"2. The only way in which a definite opinion as to the durability of such substances can be arrived at, is by submitting them in exposed situations, for a lengthened period, to the action of the weather, under conditions similar to those to which they would be placed when used as building materials. I believe that the stone is being submitted to test of this kind in England, but sufficient time has hardly elapsed since the introduction of the process to warrant a final decision as to the durability of the stone. All the published accounts, however, of the stone, which I have been able to consult, speak favourably of its enduring qualities. Moreover, judging theoretically from the nature of the materials used, and the process employed in their consolidation, stone manufactured in this manner ought to prove well calculated to resist the action of the weather.

"3. One of the chief points, however, relied on in coming to this theoretical conclusion is the fact that Ransome's stone, being composed almost entirely of siliceous matter, is capable of resisting the action of most solvents, and hence is not exposed to one of the great causes of deterioration of many building stones. The samples submitted to me, however (as will be seen by the annexed Table), contain a very large proportion of matter soluble in hydrochloric acid, the presence of which can have no beneficial effect on the durability of the stone, but, on the contrary, must, in all probability, injuriously affect it.

"4. The presence of this large proportion of soluble matter is, no doubt, due to the kind of sand employed in the manufacture of the stone. I would, therefore, venture to suggest that good siliceous sand, if procurable, should be substituted for that at present employed, and, this condition complied with, I see no reason why stone should not be made here by Ransome's process as good and as durable as that manufactured in England.

NO. OF SAMPLE.	6	7	8	9
Specific gravity of the stone ...	1.83	1.90	1.87	1.80
Percentage of water absorbed by each sample after immersion for 72 hours	1.48	.96	3.24	5.24
Percentage soluble in hydrochloric acid.....	75.99	78.96	66.57	66.85
Percentage insoluble in hydrochloric acid.....	24.01	21.04	33.43	33.15
	100.00	100.00	100.00	100.00

"I have the honour, &c.,
(Signed) "J. B. LYON, Assistant-Surgeon,
Chemical Analyst to Government."

OUR COAST DEFENCES.

THE Secretary of State for War and Inspector-General of Fortifications are at present engaged on a tour of inspection of the coast, harbour, and river defences of the kingdom, more especially on the southern, eastern, and western coasts. It is well known that opinions are vastly divided among professional men as to the form and disposition of the iron plating, both for the marine fortifications—such as the forts at Spithead—and the embrasure "shields" for the coast batteries. The great fault in points of design in the first instance with regard to most of the works on the coast that have been expressly planned to carry armour-plating is the evident overcrowding of each work with embrasures. These works, it must be remembered, built of granite, with an iron ribwork of longitudinal and transverse girders, and sheathing of outer armour, in the disposition of which each embrasure will cost from 1000*l.* to 1500*l.*, are supposed to be building to last, not for a few years, but for all time. They can neither, when once planted in the sea—like the Shovel fort in Plymouth Sound, the Spithead forts, or the fort on the Isle of Grain—be reconstructed like a fleet, or materially enlarged upon in any way. The fact is, these forts were all intended when first designed to carry the heaviest gun then known—the 23-tonner, or, as it is generally called, the 600-pounder, which has earned such fame at Shoebury. But now that the land batteries at the Gilticker, at Sandown, at Sheerness, and other points, are nearly ready to receive their iron plating, it is found that there will not be space for the 23 ton gun, and a lesser weapon will therefore have to be substituted. The same conclusions apply to the marine forts at Spithead and elsewhere. The introduction of submarine mines into the system of defence for roadsteads, harbours, and rivers has, however, rendered the failure of our marine forts to carry their originally intended weight of armament a less serious matter than it would otherwise have been, as it is just possible that all such works may in future be looked upon as grand torpedo stations, with their guns protecting the nests of hidden mines lying in the water channels and on the edges of the shoals, rather than as fighting batteries defending, unaided by any secret bedevillments, the passage from the attack of an enemy's fleet. But there are faults of overcrowding batteries with gunports in some of the works that have been, or are about to be, visited by Sir John Pakington and Sir John Burgoyne that is really unpardonable and utterly without remedy unless every alternate embrasure is built up, and half the original number of guns placed in the work. Take the costly Hilsen lines, which were designed to command the entrance to the island of Portsmouth (on which stands all the naval and ordnance establishments at Portsmouth), as an example. The embrasures have here been placed so closely together that even the earthen covering for the stone-fronted face of the batteries will not stand, so acute is the angle given by the short distance between the ports. As the earth is piled up over the top of these batteries the foundations also give way, and huge cracks

may be seen opening up through the brickwork in all directions. The want of solidity in the base to support the superstructures is, indeed, also to be found in almost every piece of new fortification now erecting, or lately erected, around our coasts. In many places this result may have been inevitable from the nature of the ground, but in many cases it has most undoubtedly been assisted by a neglect of precautionary measures, or disregard of any consideration of the condition of the soil, marsh, or shingle on which the fort was to be raised. Forts are now standing, or rather are trying to stand, which are constantly letting slip large slices of their ramparts into the ditch below. These forts carry guns, but it is almost needless to say that not one has yet been fired from their ramparts, nor could it be done with safety, for fear of the whole fort falling prostrate.

The Medway forts are, perhaps, the most curious and instructive in their history of all. They have no doubt been a bugbear and a horror to Secretaries of State for War and the officers of the Department. The so-called foundations of these works only were completed, when they split through in the most fantastic forms from their lowest to their highest stones, and had to be braced together with stout iron tie-rods from side to side to keep them from breaking up. This latter strengthening measure accomplished, the next step was to build up the superstructure. As the stones for this purpose were laid on any one side of a work it sunk in the quaking morass, while the opposite side rose. It was soon evident that no forts could be finished on the Medway's bank, but the difficulty was got rid of in a most undignified way, and in a way, too, that was peculiarly cruel to Sir John Pakington when just fresh from his labours in the "reconstruction" of the navy, and taking up his new duties as Secretary of State for War. Sir John was made to say in the House of Commons that "it had been determined to abandon the forts 'on the banks of the Medway in order that the money with which it had been intended to construct them might be expended upon the Spithead forts.'"

If Sir John Pakington visits the sites of the abandoned forts on the Medway during his present tour with Sir John Burgoyne, he will, doubtless, learn the true cause of their abandonment, and at the same time the importance of weighing carefully any statement which he may have to make officially on subjects with which he has had no opportunity to make himself personally familiar.—*Times*.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of the Iron Market for the past Week.—There has been a gradual upward motion in the prices asked and given for pig iron during the last week. During two or three days the market has been very firm and strong, and the prices have been as high as 54*s.* 6*d.* per ton cash and 54*s.* 7*d.* one month. Yesterday the market was still firm, and on Monday several thousand tons changed hands at 54*s.* 5*d.*, one month; but today the demand has again been somewhat inactive. No. 1 Gartsherrie and No. 1 Coltness have both been in demand at 61*s.* 6*d.* The shipments of pig iron at Ardrossan for the week ending 19th September were 6007 tons, including 1988 tons to supply foreign orders. For the week ending 21st September, the Glasgow shipments were 2925 tons, including 2420 tons for foreign orders. There were no shipments of pig iron at Greenock last week.

The Ocean Race from China—more Greenock Ships Successful.—The Taeping, mentioned last week, is not to be allowed to claim the victory this year, after all, in the exciting race among the China tea clippers. On Sunday morning last the clipper ship, Sir Lancelot, arrived in the Downs from Shanghai, after a run of 96 days. Now, Shanghai is more distant by 700 miles than Foo-choo-foo, and consequently the passage of the Sir Lancelot has put that of the Taeping completely in the shade. The Sir Lancelot is a vessel of 885 tons, is owned by Mr. John McCunn, of Greenock, and was built by Messrs. Robert Steele and Company in 1865. She came home by the eastern passage. The Ariel, 750 tons, also built by the builders of the Taeping and the Sir Lancelot, in 1865, arrived home on Monday, and completed the passage in seven hours less than the time taken by the Taeping. Such a close race over such a long course is, according to the *Times*, absolutely unprecedented. Captain Dowdy, the commander of the Taeping, is to be entertained at a grand banquet by the Fishmongers' Company, in honour of his great success.

Another exciting race is expected between two more Clyde-built China clippers, the Lah-loo, built by Messrs. Steele and Co., of Greenock, and the Spindrift, built by Messrs. Connell and Co., of Glasgow. They were to have started on their first voyage last week simultaneously from Gravesend, for Shanghai; the Spindrift, however, started two days before her competitor. The Greenock clipper-building firm is getting great praise.

Further Reduction of Fares to and from Belfast.—Messrs. G. and J. Burns are determined not to be beaten off by the Ardrossan Steamboat Company in the matter of cheap fares. They have just put on their screw steamer Wensel, in addition to their two ordinary mail steamers, to run to and from Belfast at 4*d.* per voyage by deck passage, and 2*s.* 6*d.* cabin, including railway to or from Greenock. Can travelling further go in the direction of cheapness? The Wensel had upwards of 600 passengers on Saturday last, when she made her first trip from Greenock. The Wolf sailed shortly afterwards, stowage, 1*s.*; cabin, 12*s.* 6*d.* Between them they had considerably upwards of 1000 passengers. It is worthy of note that on Saturday evening last no fewer than four sea-going steamers belonging to Messrs. Burns, were lying at the Greenock pier—the Wolf and Wensel for Belfast, the Buffalo for Londonderry, and the Penguin for Liverpool.

The nightly average by the Ardrossan route exceeds 400, at a sixpence each. To get to Ardrossan from this city by railway, now, at a cheap rate, is to go by way of Belfast, or at all events to take a sixpenny instead of the usual half-crown ticket. It is to be hoped that some good friend of these competing companies will step in and prevent them repeating the deed done by the "Kilkenny cats."

Shipbuilding and Shipping Items, New Contracts, &c.—The new steamer *Baltimore*, 2200 tons, lately built at Greenock for the North German Lloyd's Company, for their Bremen and Baltimore line of steamers, has just been towed over to Gareloch to await the arrival of the steel shaft which is being made for her in Prussia.

The *Jasper*, a handsome new iron three-masted schooner, built by Messrs. Robertson and Co., of Greenock, for the Mersey and Clyde line of traders, owned by Messrs. McArthur Brothers, of Glasgow, has also been over to Gareloch for the adjustment of her compasses.

A fine ship of 1250 tons, named the *Arigowan*, was launched by Messrs. Robert Steele and Co., on Thursday last, for Mr. George Adam, Greenock. Her dimensions are: length of keel, 212 ft.; breadth of beam, 35 ft.; depth of hold, 32 ft. She is intended for the East India trade.

Messrs. Seath and Connell, shipbuilders, Rutherglen, launched a handsome screw steamer, the *Silver River*, of 441 tons register, last week. She has been brought down to the upper harbour of this city, to receive her engines and machinery, and to be thoroughly finished. Her engines are to have surface condensers with all the latest improvements, and a high rate of speed is expected of her. She is two-decked, and is the largest vessel that has hitherto been built up the river. When the new Hutcheson Bridge is built (of which more shortly), and the weir near its intended site is removed, it is expected that the shipbuilding yard at the ancient royal burgh of Rutherglen will be able to turn out vessels of double the tonnage of the *Silver River*. Notwithstanding the present depression in the shipbuilding trade, Messrs. Seath and Connell have in hands at present one screw steam yacht of 50 tons, another of 60 tons, and two twin screws of over 200 tons each.

As further evidence of the great activity in the Greenock shipping trade, there were no fewer than seventeen arrivals from foreign ports, with a total tonnage of 5600 tons, between Saturday night and Monday last. Four had cargoes of apples, one had wine, three wheat, four timber, and two sugar.

The *Medora*, a finely modelled ship was launched a few days ago from the shipyard of Messrs. Barr and Shearer, Ardrossan. She is about 800 tons register, and is classed A 1, thirteen years, at Lloyd's. She is intended as an addition to the extensive fleet owned by the eminent shipping firm, Messrs. James and Alexander Allan, of Glasgow.

The screw-steamer *Denmark* was recently launched by Messrs. Henderson, Coullborn, and Co., of Renfrew, for the Baltic grain trade. Immediately after being launched, she was placed in the builders' tidal basin, under their steam crane, and received her machinery and boilers. After taking a short trial-trip, she sailed to Liverpool, and steamed to the Bell Buoy at an average rate of ten knots on a consumption of 9.75 cwt. of coal per hour. The *Denmark* is constructed to carry from 4000 to 4500 quarters of grain. She is fitted with compound high and low pressure engines of 100 horse power nominal, with surface condensers and other improvements. Her builders have just received very favourable reports regarding the voyage to Japan of the steamer *Dragon*, built and engined by them. Their new system of machinery seems to have proved to be possessed of very decided advantages. The *Dragon* has performed what has never been done before, the last place she sailed at being the Cape of Good Hope.

Messrs. Robertson and Co., Greenock, have contracted for the building of a tug steamer of medium size. She is for the Glasgow and Greenock Company, of which Messrs. Steele, Glasgow, and Cunningham and McCaskill, Greenock, are the managing owners. The engines are to be built by the Finnieston Steamship Foundry, Glasgow, and considerable interest is taken in this contract to see if the Clyde cannot produce a tug-boat as light and cheaply as the Tyne ship-building firms.

Messrs. Robert Steele and Co. have contracted with Messrs. James Richardson and Co., sugar refiners and merchants, Glasgow and Greenock, to build two ships of about 800 tons, for their Mauritius and West Indian trade. They are to be similar to the *Electwood*, built this year by them for Messrs. Richardson. Messrs. Steele during the past fortnight contracted for other two ships, one of 1200 tons for Messrs. Shankland and Co., Greenock, and another of 1000 tons for Mr. D. Hendry and others, and they have another sailing vessel of about 600 tons for a Liverpool house on the stocks.

Messrs. Randolph, Elder, and Company have just concluded a contract with the Aberdeen, Leith, and Clyde Shipping Company, to build a screw steamer of 700 tons, for the passenger trade between Leith, Dundee, and Aberdeen. She is to be of 200 horse power, 200 ft. long, 26 ft. 6 in. broad, and 14 ft. in depth of hold, and is to have accommodation for fifty first-class passengers.

New Iron Bridge near Berwick.—A lattice-girder iron bridge is at the present time being erected across the Whitadder, about four miles from Berwick, the wooden bridge having been condemned. The engineer for the work is Mr. Leslie, C.E., Edinburgh; and the contractors, Messrs. Cowper and Brodie, Paisley. The estimated cost of the bridge was upwards of 3530*l.*, and it was to be completed by the end of this month. However, several causes have operated to prevent the work being completed at the stipulated time. Considerable difficulty has been experienced in finding a foundation, and instead of eight cylinders being sufficient for each pier, twelve will be required. Then, again, the bridge is being built on the site of the old one, and great difficulty was experienced in drawing the piles on which the wooden bridge was built, four days having been occupied in drawing one pile. Another delay arose from the fact that this is the first iron bridge of the kind built in the neighbourhood, and great ignorance prevailed among the workmen as to the sinking of the cylinders. It is expected that the bridge will be completed by Christmas, and that the estimated cost will be exceeded by 800*l.*

New Hutchesontown-bridge over the Clyde.—The estimates for the building of the new iron bridge, in room of the present Hutchesontown stone bridge, were opened to-day at a

meeting of the Bridge Trustees. There were ten estimates received, and they all come very close upon one another; but report has it that in every case the estimated cost given by Messrs. Bell and Miller, the engineers, is exceeded, which was 42,000*l.*, including the building of the wooden accommodation bridge, which I mentioned, I think, a number of weeks since, as having cost 3600*l.* The estimates were opened in presence of the trustees; but they did not come to any conclusion in reference to the accepted offer. They will meet again on Friday.

Cleland and Mid-Caldor (Caledonian) Railway.—The West Calder contract of this line, undertaken by Mr. John Waddell, Bathgate, has made great progress towards completion within the last two or three months. On Monday an engine was run all the way between Mid-Caldor and Addiewell, and it is expected that the line will be opened for goods traffic within two months, and for passenger traffic by the 1st January next.

PRUSSIAN COAL.

THE coal-fields of the valley of the Ruhr extend over a surface of 115 square miles, and are supposed to contain about 40,000,000,000 tons of fuel. The production in 1855 amounted to 3,252,223 tons (British), and the number of hands employed was 22,235; in 1865 the production reached 8,535,614 tons, having nearly trebled itself in the ten years, and the number of hands employed had increased to 39,871. The price of coal at the pit's mouth was, on an average, for best, 5*s.* 6*d.* per ton in 1866. The wages of the coal districts vary from 11*s.* 6*d.* (about 13*d.*), for boys, to 2*s.* and 2*s.* 6*d.* for men for a day of ten hours. Labourers who earn more do so by extra exertion in the mines where piecework is usual. The difference between the district and similar ones in England is that you find there cheaper wages and longer hours of work—consequently, cheaper coal at the pit's mouth than in Great Britain. The carriage of coals on railways being on an average four-fifths of a halfpenny per ton per mile, and the chief centres of Rhenish industry being close to the collieries, machinery can be driven less expensively there than in England. A net of railways unites the collieries with all the great towns of the neighbourhood—Duisburg, Düsseldorf, Elberfeld, Barmen, Hagen, Iserlohn, Witten, Dortmund, Essen, and Ruhrort. A steam ferry takes the coal over the Rhine at Ruhrort into the silk and cotton manufactories of Crefeld, Viersen, and Gladbach. At Ruhrort a vast harbour, formed by the confluence of the Ruhr with the Rhine, serves as port of shipment for the coal, which is towed up to Mayence and Mannheim in barges. At Duisburg shipments are made from the quays of the Rhine. The war of 1866 curtailed the facilities of transport, and withdrew men from productive labour, and the hands employed on the Ruhr coal-fields were reduced to 37,686; but through a more general use of machinery the production of the year still slightly increased, and reached 8,583,302 tons. New railways increase the export of produce, and year by year the area over which the export of Ruhr coal takes place is extended. "It is urgent," writes Consul-general Crowe, of Leipzig, from whose recent report to the Foreign Office these statements are taken, "that our trade should know that little or no English coal is now sent inland from Antwerp, Rotterdam, or any of the Dutch and Belgian harbours. The Ruhr collieries feed the great industrial centres of the Lower Rhenish provinces, and compete with England in the Dutch and North German markets. The coal-owners are striving for new communications to the westward, and there is no doubt that if they could rival England in the quality as well as in the price of coal they might push us hard enough in certain quarters. They admit the superiority of English sea coal, but they may, and perhaps do, calculate on the possible exhaustion of Great Britain. It is scarcely possible to describe the pleasure and excitement caused in the Ruhr districts by the fact that in 1865 and 1866 Westphalian coal was carried with profit to the Belgian coal basins of Charleroi and Mons, and even over the frontier into France. It is a small matter at present, but France may not be able to get more out of her own fields, and England and Belgium be unable to deliver cheaper and in larger quantities." A few words concerning the labourers in the Ruhr coal districts will be of interest. A great number are vagrant. They do not universally keep to mining as the business of their life. They are prone to change, and you will find the same hand turn to two or three different occupations in the same number of years. They have as yet shown no desire to combine or to form trades' unions. There is nothing organised among them, except a society for advancing necessities on a certainty of repayment from wages at monthly intervals. The workmen complain of competition among each other. The owners of mines, on the contrary, complain that labour is too scarce, and threatens to be too dear, so that there are limits to the expansion of works. As for the coal mines themselves, there are none that exceed 150 fathoms in depth; some have double, most have but one shaft divided by hoardings into halves for the passage of air and the working of the cars. Substantial buildings cover the shafts, and contain the necessary steam-engines and boilers. The seams are numerous, and are worked at various levels from the same shaft. Some seams are as thin as 24 ft.; the thickest are rarely above 43 ft. The quality of the coal is various.—*Times*.

COAL-CUTTING MACHINES.

TO THE EDITOR OF ENGINEERING.

SIR,—Under the above head, your correspondent, "J. G.," gives a statement of the working of certain coal-cutting machinery at West Ardsley, near Leeds, but his very sanguine anticipations as to the results attainable by the machinery he describes appear to me to be very far-fetched, and, taking his own statements, altogether erroneous. The machinery described by "J. G." performs the opera-

tion of holing, kirving, or undercutting at a long bank, and to this one operation its action is confined, with the further limitation that the height of the drift in which the machine is used must be at the very least 3 ft. or more, in order to admit the attendant, who has to set on the machine while working it.

Now kirving at long walls is only one of the many and varied cutting operations that have to be performed by hand labour; it is only of limited application, and is the easiest and most straightforward part of the collier's work in cutting. If the machines will only perform this work, and that, too, only where the seam is over 3 ft. thick, then it is too much to say that such machines will "supercede the present system of hand-pick labour," and have "passed the stage of experiments." The machinery described by "J. G." requires the drift and road in which it has to work to be first made by hand labour. This is the slowest and most difficult part of the collier's work, and cannot be performed by the machinery described, which requires the completed road to work on. Until this is accomplished by the coal-cutting machine, it cannot be considered a success, and "passed the stage of experiments."

I have already stated that long wall working is of only limited application. I suppose it is scarcely necessary for me to explain that the systems of working coal mines have to be varied considerably, according as the quality and structure of the different coal strata may render necessary. Hence we have various modifications of the system known as "pillar and stall," as well as modified forms of the long wall system, in none of which the West Ardsley machinery, as described by "J. G.," could be employed. Again, the thin seams, some of which are only 18 in. or less, in which the use of the machine would be of greatest advantage in the making less small, must be altogether shut out from the use of a machine which has to be worked by an attendant seated thereon.

"J. G." also speaks in terms of approval of the system of roof-pressure used in one of the West Ardsley machines, in order to obtain a sufficient "purchase" for the action of the cutter. This appears to me in itself sufficient to condemn the machine, as the roofs in most coal mines are generally dangerous enough of themselves, without increasing the risk by blows from a machine.

The objections I have pointed out are, I think, sufficiently obvious, and will prevent the general application of the machinery described by "J. G." We may, however, anticipate some good results from the competitive trials of coal-cutting machines, which are to commence in November next, in Lancashire, under the direction of the South Lancashire and Cheshire Coal Association. In all probability, these experiments will result in the production of a machine which will perform all the operations above referred to.

X. Y. Z.

[As the writer of the above withholds his name, it is but right that we should say he is a patentee of a coal-cutting machine, whereas "J. G." has no pecuniary interest in the question.—Ed. E.]

FRENCH MARINE ENGINES.

TO THE EDITOR OF ENGINEERING.

SIR,—Some weeks ago, while perusing, in the columns of *The Engineer*, a description of M. Dupuy de Lome's three-cylinder compound engine for the French ironclad, the *Friedland*, my attention was forcibly arrested by the following paragraph:

"In comparing the power exerted by the high and each of the low-pressure cylinders, we must remember that, whilst the former has a force acting with perhaps 30 lb. to the inch on one side of its piston, in the latter the piston is propelled by the expansion, and drawn by the condensation, with forces which, in the aggregate, fall little short of that which is applied to the high-pressure piston." (*Vide The Engineer*, July 19, 1867, page 58.)

The article in question, which purports to be a general review of French marine engineering, is rather lengthy, and ranges over a variety of topics, each in itself of sufficient interest to claim special attention, and room for much thought to the serious reader; but the novelty of "a piston propelled by the expansion, and drawn by the condensation, with forces," ever and anon recurred to my mind, and finally compelled me to pause in my studious career, in order that I might unravel the meaning of that sentence.

The Engineer is not necessarily a grammarian, and he may with impunity, as an engineer, speak or write of a piston as being propelled by the expansion with forces, or propelled by the expansion of forces, because the reader will generally understand his meaning; but though not necessarily a philosopher, the engineer in general, and your contemporary in particular, who writes for the information and for the instruction of all interested parties, ought to have sufficiently clear notions of mechanical science to convey his ideas in language intelligible to mechanical scholars of the humblest degree; and here I would ask the editor of that journal what is meant by a piston drawn by the condensation with (or of) forces, or whether he means to convey the idea that the condensation of steam in front of a piston is a phenomenon similar to that of the muscular action of a horse or a jackass in front of a common cart, and, if so, what author on elementary mechanics has established the same comparison?

Absence from home, and the hope that some one better qualified than myself might take up the subject, has prevented me from calling the editor of *The Engineer's* attention to this matter, which I must needs do through the columns of your paper.

I remain, Sir,

Yours very truly,

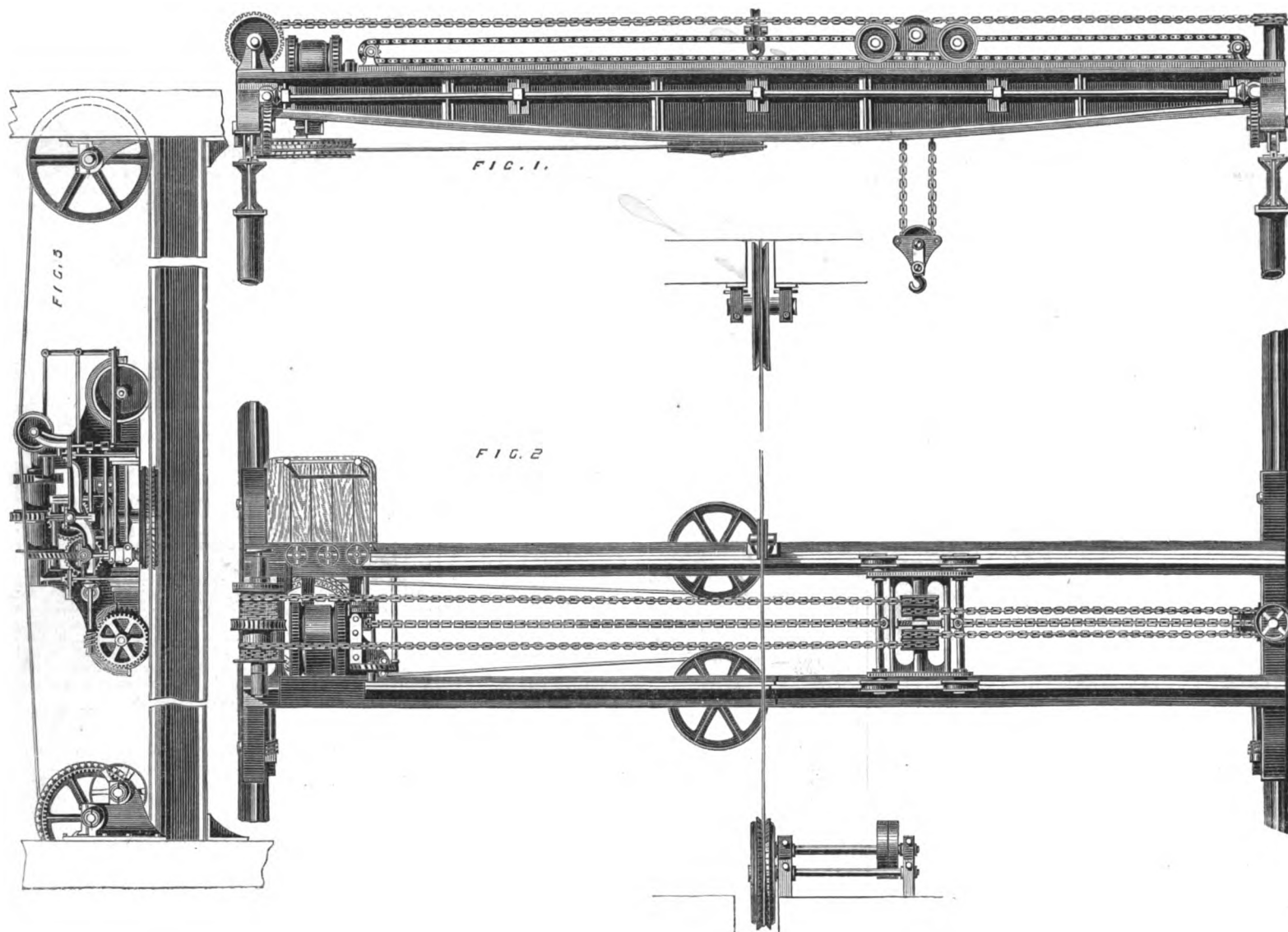
London, September 25, 1867.

J. J. BIRCKEL.

RAILS FOR RUSSIA.—The John Cockerill Company, of Seraing, and MM. Blondiaux and Co., of Thy-le-Château, have secured a Russian order for 20,000 tons of rails, with accessories. The rails are to be used in Southern Russia.

TRAVERSING CRANE AT THE STEAM-PLOUGH WORKS, LEEDS.

MESSRS. JOHN FOWLER AND CO., ENGINEERS.



In the course of the account which we gave last week of the Steam-Plough Works, Leeds, we mentioned a traversing-crane, which is worked by a steel rope acting upon a clip-drum. Of this crane, which is made to lift weights up to 12 tons, we now give engravings on the present page. As will be seen by the illustrations, the wire rope, which is $\frac{1}{2}$ in. in diameter, and is run at a speed of about three miles per hour, passes round guide-pulleys running on studs fixed to the underside of the crane; and from these it is led round the clip-drum, which is placed near one end of the crane-girders. The hoisting and traversing motions of the crane are driven from the shaft carrying the clip-drum by means of frictional gearing, the arrangement of which can be readily traced out from the figures. Every motion is driven by a worm, and a load is lowered simply by reversing the direction of running. Each of the motions is arranged so that it can be run at two speeds.

The endless rope by which the crane is worked passes over a clip pulley at one end of the shop, and a plain grooved pulley at the other, the driving power being applied through the former pulley. The return rope is led over the top of the crane, which latter carries a guide pulley to support it.

The endless rope is kept running continuously, as, at the moderate speed at which it is worked, but little power is required to drive it when the crane is at rest. It is, in fact, the employment of a slow running rope combined with the clip drum that constitutes the main feature of the arrangement. At present, the crane which we have described is the only one driven by the rope in its particular department of the Steam Plough Works, but Messrs. Fowler and Co. are erecting another crane which will be driven from the same rope. In fact, any number of cranes can be driven by one rope, provided that they are in the same building. Our engravings of the crane we have described have been prepared from tracing with which we have been supplied by Messrs. J. Fowler and Co.

WINCHESTER DRAINAGE COMPETITION.

TO THE EDITOR OF ENGINEERING.

SIR,—Of the many ills which flesh is heir to, and the frequent annoyances and vexations that fall to the lot of man, I think that the most offensive of all to your true Briton is to be “done,” taken in, promised fair, but played false. Such, however, has been the treatment which ourselves and eight other gentlemen have lately received from the Local Board of Winchester in the matter of the competition designs for the drainage of that city.

In September last year, the Winchester Local Board advertised for plans, sections, estimates, &c., for the complete drainage of their city, offering premiums of 150*l.*, 100*l.*, and 50*l.*, for the first, second, and third best designs respectively, which were to be in accordance with “printed particulars” supplied. These set forth various stipulations, but three only I need now mention as being special, and affecting the engineering part of the question. 1st, that the estimates were to be divided into three sections according to the locality; 2nd, that “the designs were to set forth the best place and “method of disposing of the sewage;” and 3rd, that “the plans and horizontal sections were to be drawn to a scale of “66 ft. to an inch.”

Upon this we visited and stayed about a week in Winchester, and spent a considerable sum of money, and a great deal of time and trouble, in getting up our designs, which trouble was greatly enhanced by the scale being required to be so large, and there being no accurate map or levels of the city to be obtained except from our own observations. On the 1st January, 1867, eleven competitive designs were sent in.

After some weeks the Local Board referred all the plans to their surveyor for his examination. On the 4th April he made his report, finding considerable discrepancies and faults with all, more or less, but stating that one (No. 3) “did provide for the safe and unobjectionable application of the “sewage, which was the great desideratum.”

The Local Board, upon this, took no notice whatever of their surveyor's report, but selected four plans (which all utilised the sewage in the same place), and discarded the other seven, including No. 3, which their surveyor recommended, though its retention with the four selected was voted for by five of the members. These four (Nos. 1, 5, 7, and 11) they submitted to Mr. Bothams, the city surveyor of Salisbury, for him to select the three best for first, second, and third premiums.

Mr. Bothams kept these four plans for some three or four months, and, on July 15th, made his report, setting forth the various qualities of each, and recommending No. 7 as the best, and, being asked by the committee various questions, and amongst them one somewhat of a leading question, he replies that he does not think that Nos. 1, 5, and 11 are entitled to any premium at all. This is confirmed by the Local Board, upon which they determine to withhold entirely the 2nd and 3rd premiums.

There were two amendments proposed at the meeting, one of which was that the whole of the rejected plans should be

recalled and submitted to a Government inspector from the Local Government Act Office, and the other amendment moved the adjournment of the question for a month, in order to consider it more deliberately. The first was negatived by 12 to 5, and the latter by 10 to 7.

Now, Sir, we contend that whatever right the Local Board had to put a veto on this or that plan, for the first premium—the one which they intend to carry out—they were not competent to judge on the question (then become purely a question for an engineer) of the merits of the other plans, for the allotment of the second and third prizes, and they were unjust to discard the seven without submitting them to an engineer.

Again, with the four selected—they selected them themselves, with their eyes open, and all their amateur engineering knowledge, combined with an intimate acquaintance with the “printed particulars”—and now they sneak out of their obligations with the paltry excuse that the designs are not in accordance with those “printed particulars.” How is it that they did not see this fact when they selected Nos. 1, 5, 7, and 11?

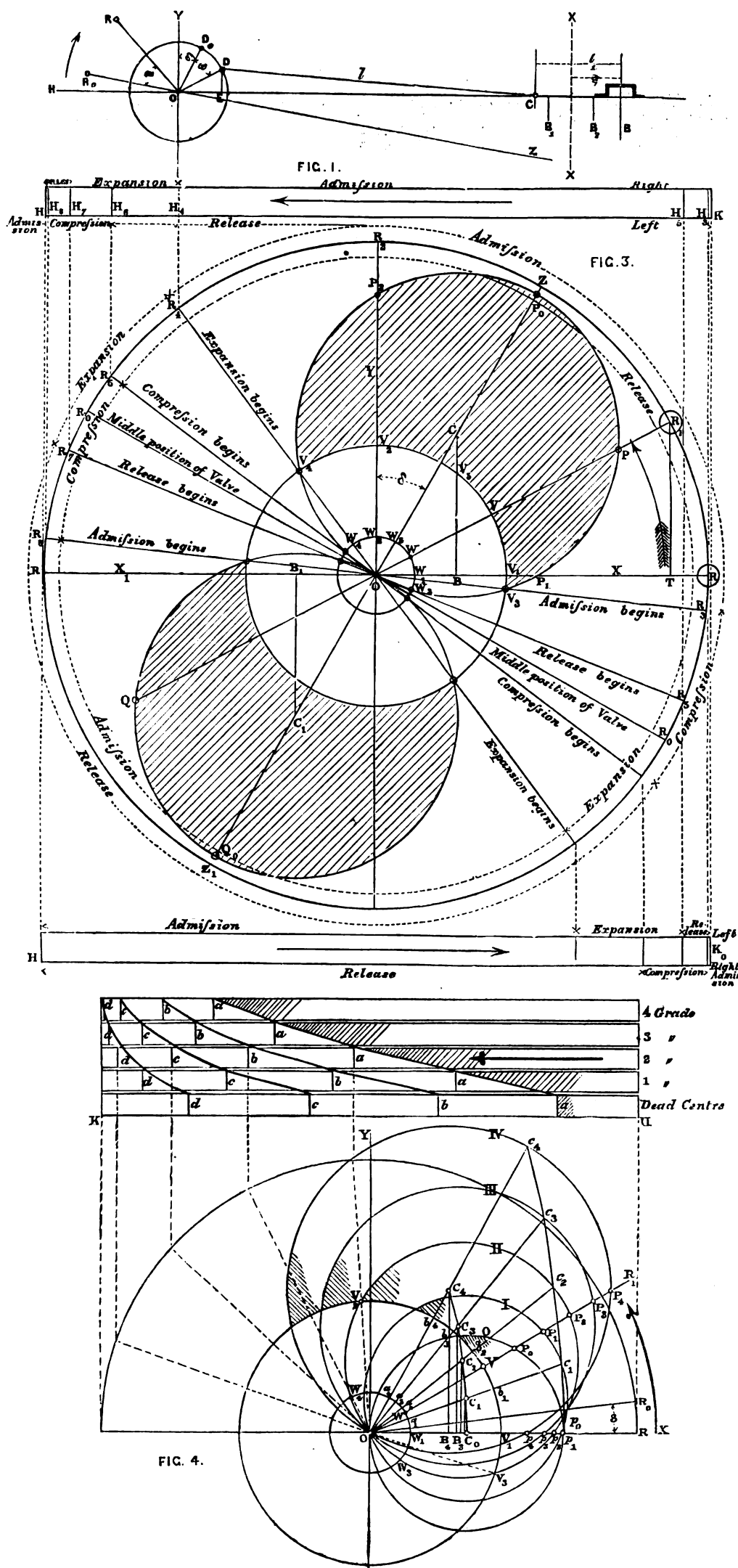
As to the few inaccuracies in the levels, considering the absence of all reliable information from any plans and sections existing, it was almost impossible to avoid some errors in levelling over so large a place as Winchester in the time available.

In architectural competitions it is very different, for an architect (in most cases at least) can sit down at his office table, and get out his design without even going near the *locus in quo*; but an engineer must not only go and see the place, but must spend a considerable time there, and money out of pocket in addition to that required in getting up the drawings in his office. Therefore we say that these gentlemen have obtained the work of our brains and hands from us, in good faith on our part, and have most disgracefully played us false, and kept back that which is our due, and which some two among us have justly earned, for the sake of saving 150*l.*!

We don't hesitate to say, Sir, that there is not a man among them who in his private capacity would have thought for a moment of such meanness, and an individual who could be guilty of such a breach of faith would become the reproach of his fellow-citizens, and disgraced in the sight of all honourable gentlemen.

Apologising for occupying so much of your valuable space,
We are, Sir, your obedient Servants,
VICTIMS OF MISPLACED CONFIDENCE.

PROFESSOR ZEUNER'S VALVE DIAGRAM.



PROFESSOR ZEUNER'S VALVE DIAGRAM.

TO THE EDITOR OF ENGINEERING.

SIR,—The following particulars of Professor Zeuner's valve diagrams will perhaps be interesting to many of your readers.

In investigating the action of a slide-valve, we shall have in the first place to ascertain its travel; in other words, to find for any angle of rotation the distance of the valve centre, B, from the centre of oscillation, X. If the valve be adjusted for equal lead, the centre line of oscillation, X, must be situated central between the ports and at a fixed distance from the axle, O.

In Fig. 1, letters denote:

- O=the centre of the driving axle.
- OR=the radius of the crank.
- OD=r=the throw of the eccentric.
- DC=l=length of eccentric-rod.
- CB=l₁=length of valve spindle.
- OZ=axis of cylinder.
- δ=the angle of lead.
- ω=the angle of rotation.

We have:

$$\begin{aligned} OB &= OE + EC + CB, \\ &= r \sin(\omega + \delta) + \sqrt{l^2 - r^2 \cos^2(\omega + \delta)} + l_1, \\ &= r \sin(\omega + \delta) + l \sqrt{1 - \left(\frac{r \cos(\omega + \delta)}{l}\right)^2} + l_1. \end{aligned}$$

This, analysed into a series, according to formula

$$\sqrt{1-x^2} = 1 - \frac{1}{2}x^2 + \dots$$

gives

$$OB = r \sin(\omega + \delta) + l \left\{ 1 - \frac{r^2 \cos^2(\omega + \delta)}{2l^2} \right\} + l_1.$$

Since the valve oscillates symmetrically on the central line, X, it follows that at the angles of rotation, ω, and 180°-ω, the valve centre line is situated at equal distances, but in opposite directions, from the central line, X.

Substituting in the last for ω=0°, we have

$$OB_1 = r \sin \delta + l \left\{ \frac{1 - r^2 \cos^2 \delta}{2l^2} \right\} + l_1;$$

and for ω=180°, we have

$$OB_2 = -r \sin \delta + l \left\{ 1 - \frac{r^2 \cos^2 \delta}{2l^2} \right\} + l_1;$$

since

$$\frac{OB_1 + OB_2}{2} = OX,$$

we have

$$OX = l \left\{ 1 - \frac{r^2 \cos^2 \delta}{2l^2} \right\} + l_1.$$

The travel, ξ, of the valve for the angle of rotation, ω, is:

$$\begin{aligned} \xi &= OB - OX \\ &= r \sin(\omega + \delta) + \frac{r^2}{2l} \{ \cos^2 \delta - \cos^2(\omega + \delta) \} \\ &= r \sin(\omega + \delta) + \frac{r^2}{2l} \sin(2\delta + \omega) \sin \omega \end{aligned}$$

r and l being usually so proportioned that the disturbances caused by the obliquity of the eccentric-rod become practically inappreciable, we can neglect the value $\frac{r^2}{2l} \sin(2\delta + \omega) \sin \omega$,

and have $\xi = r \sin(\omega + \delta)$,
 $= r \sin \delta \cos \omega + r \cos \delta \sin \omega$;
 or simpler when A denotes r sin δ, and

B " r cos δ.
 $\xi = A \cos \omega + B \sin \omega \dots (1)$,
 which is the polar equation of two tangential circles of equal diameter, the pole being in the point of contact.

Referring to Fig. 2,

$$\begin{aligned} \xi &= r \cos \phi \\ &= r \cos \{ 90^\circ - (\omega + \delta) \} \\ &= r \sin(\omega + \delta), \end{aligned}$$

and we have geometrically arrived at the same equation as above; therefore the travel of the valve for any angle of rotation is represented by its corresponding radius vector.

For the value of A and B we have in Fig. 2,

$$\begin{aligned} OF &= r \cos \delta = B, \\ OE &= r \sin \delta = A, \end{aligned}$$

and the co-ordinates for the centre of the circle are

$$a = \frac{1}{2} A \text{ and } b = \frac{1}{2} B.$$

I. The action of an ordinary slide-valve driven by a single eccentric.

Given the radius of eccentricity (r) = $2\frac{1}{2}$ in.
the outside lap = $\frac{1}{4}$ in.
the inside lap = $\frac{1}{4}$ in.
the angle of lead (δ) = 30°

To construct the diagram (Fig. 3) draw the system of axis OY and OX, of which OX denotes the centre line of motion; then draw the line OZ at an angle of 30° (equal to the angle of lead) to OY, and upon it and its continuation (OZ) mark off the amount of eccentricity (r) OP₀ and OQ₀, and over OP₀ and OQ₀, as diameters describe two circles. By means of these circles (by Zeuner called *schieberkreise*, or *valve circles*) the motion of the valve and the distribution of steam is explained in the following simple manner:

Supposing the crank to be in the position of OR, or in the first of its dead centres, and rotating in the direction of the arrow from R to R₁. Arrived in R₁, the corresponding travel of the valve will be OP₁; in other words, OP denotes the distance the valve has travelled from its central position.

For the angle of rotation, XOQ, or $(180^\circ + \omega)$ the diagram gives the same value negative. The upper circle gives us the travel of the valve to the right-hand side, and the lower circle that to the left-hand side, from the central line of oscillation.

The valve oscillating symmetrically on a central line, X, it follows that both circles give similar values, and for the sake of simplicity we will only consider the upper circle.

The diagram being drawn full size, we need only measure the distance OP to find the distance of the valves; likewise, by measuring OP₁, on the line OX we find the position of the valve from the central line, when the crank is at its dead centre.

To get the opening of the port, describe around the centre, O, a circle with a radius, OV, equal to the outside lap, and subtract OV from OP.

The opening of the other port for the release we find by describing another circle around the centre, O, with a radius, OW, equal to the amount of inside lap, and by subtracting OW from OP.

All other questions can be solved by referring to diagram Fig. 3.

II. The action of a slide-valve driven by a link-motion.

The travel of the valve, ξ , is expressed by the equation

$$\xi = r \left(\sin \delta + \frac{c^2 - u^2}{cl} \cos \delta \right) \cos \omega + \frac{ru}{c} \cos \delta \sin \omega,$$

where r = throw of eccentrics,
 c = distance from centre of link to point of connexion with eccentric rod,
 u = distance from centre of link to guide block,
 l = length of eccentric rods,
 δ = angle of lead,
 ω = angle of rotation;

the link motion is arranged on Stephenson's principle, and the link is connected to the eccentric rods, so that u can be equal to c .

$$\text{If } r \left(\sin \delta + \frac{c^2 - u^2}{cl} \cos \delta \right) = A, \text{ and}$$

$$r \frac{u}{c} \cos \delta = B,$$

we have by substituting these values in above formula

$$\xi = A \cos \omega + B \sin \omega.$$

In diagram, Fig. 4, we have assumed 4 degrees of expansion or notches, and by referring to the diagram we can compute the subjoined Table, where all the values are given full size.

	Dead centre.	Degree of Expansion.			
		1.	2.	3.	4.
Travel of valve...	OP ₀	OP ₁	OP ₂	OP ₃	OP ₄
Opening of steam-port...	VP ₀	VP ₁	VP ₂	VP ₃	VP ₄
Opening of release-port...	WP ₀	WP ₁	WP ₂	WP ₃	WP ₄
Outside lead ...	V ₁ p ₀	V ₁ p ₁	V ₁ p ₂	V ₁ p ₃	V ₁ p ₄
Inside lead ...	W ₁ p ₀	W ₁ p ₁	W ₁ p ₂	W ₁ p ₃	W ₁ p ₄
Maximum travel of valve	OP ₀	OC ₁	OC ₂	OC ₃	OC ₄
Maximum opening of steam-port ...	V ₁ p ₀	b ₁ c ₁	b ₂ c ₂	b ₃ c ₃	b ₄ c ₄
Maximum opening of release-port ...	W ₁ p ₀	a ₁ c ₁	a ₂ c ₂	a ₃ c ₃	a ₄ c ₄

Sheffield, September 12, 1857.

A. B.

GOLD AND SILVER IN NICARAGUA.—Attention has been a good deal occupied of late with the gold and silver mines of Javali, discovered in the mountainous district of Chontales, which belongs to the Republic of Nicaragua, and which is at no great distance from the Atlantic Ocean. The part of the mines already worked is in the hands of English capitalists, who have impressed great activity on the operations. Specimens of the gold and silver raised are understood to have been forwarded to England.

TRANSATLANTIC STEAM SHIPPING.—The number of great lines of Transatlantic steamers sailing from Liverpool has just been increased by an enterprise inaugurated by an American company between Liverpool and Boston. For some few years, Anglo-American maritime commerce has been in the hands of great English companies, who have succeeded in getting rid of all foreign competition. But since the close of the civil war of 1861-65, the intercourse between Great Britain and the United States has acquired so great an extension that, notwithstanding a recent increase in the plant of the Cunard, Inman, &c., companies, capitalists of Boston—a port which required, for the rest, a direct line with Liverpool—have deemed it right to make a trial on their own account. The first voyage has been made by the Ontario, a screw of 2289 tons. Another steamer, the Erie (3000 tons), is nearly completed; and a third, the Superior (3000 tons), is in course of construction.

THE MISSISSIPPI BRIDGE AT ST. LOUIS.

In our last number we mentioned the committee of American engineers which has been convened to determine upon the best method of constructing the foundations of the great bridge which is to be constructed across the Mississippi at St. Louis. The committee on the foundations and piers was composed of Messrs. E. S. Chesboro, William J. McAlpine, George A. Parker, L. J. Fleming, C. L. McAlpine, and General W. S. Smith; and a meeting of this committee was held at St. Louis on the 21st of August last, there being present Messrs. Chesboro, W. J. McAlpine, General Smith, and C. L. McAlpine.

On motion, Mr. Chesboro was unanimously elected chairman, and C. L. McAlpine, secretary, and was requested to make notes of the observations of the members under the direction of the chairman.

It was decided that the discussion should be with open doors, and that any member of the convention, or any person interested in the subject who expressed a desire to that effect, should be invited to be present during the discussions.

Messrs. T. J. Homer and J. B. Moulton, of the committee on the "Regimen of the River and Character of its Bed," were invited to attend, when they stated to the committee the results of their own investigations, and that of others, extending over a course of many years, as to the following among other points, namely: The periods and action of the floods in the Mississippi river; the character of the material forming the bed and sides of the stream; the disposition and amount of scouring and silting, and the causes, so far as came within their observation; their opinion as to the extent of the same, that would be due to the erection of piers for the proposed bridge; the movement and effect of ice and ice gorges, and the information gained by Mr. Homer, during his soundings and borings in the river and its bed, from the mouth of the Missouri to Jefferson Barracks, and particularly in regard to the certainty that the rock found below the bed of the river, at the depth shown on his cross sections, was rock in place, and not boulders.

The practical experience of the members of the committee in the construction of works similar to the one proposed, the recorded experience of eminent engineers in this and other countries, and the particular information obtained in regard to the case in question, was dwelt upon with great care and deliberation by the committee. Many plans of the latest improvements for foundations and piers were brought forward for discussion. Among the first considered were those of coffer dams. Allusion was made to several that had been constructed in deep water, and under various difficult and perplexing circumstances. Among the rest a coffer dam built by Colonel Abert on the Potomac river at Georgetown, which was about 40 ft. in depth, another, built by Mr. Jervis for the Croton Aqueduct, at Harlem river, about 50 ft. in depth, another, built for the U.S. Naval Dry Docks, at Brooklyn, by Mr. McAlpine, 50 ft. in depth, and several others built in this country and abroad were cited, and brief descriptions given, and their relative merits discussed.

It was finally determined that their use here in the rapid currents, deep water, high floods, and the treacherous nature of the river bed would be attended with great expense and hazard.

The plan of the foundations of the Connecticut River Bridge and others similar to it was then taken up and fully discussed. These piers were built upon a massive grillage of timber, which was suspended by iron screw rods, and lowered to its place as the masonry was being built upon it. When the grillage reached the bottom it rested upon wooden piles, previously driven and cut off under water just above the scour line of the bed of the river.

It was ascertained by calculation that two hundred and ten (210) piles, penetrating to a depth of 28 ft. below scour line, would be required to give the requisite support to one pier of the proposed bridge and its load.

It was also agreed upon that, in the opinion of this committee, provision should be made in all of the plans that might be considered for a possible scour in the bed of the stream along the side of the piers to the extent of at least 40 ft. below low water, but, to provide for all possible contingencies, they would consider this depth to be 45 ft.

The weight of one of the heaviest piers was ascertained to be about ... 6000 tons.
And the weight of the superstructure, and the moving load which it would have to support, about ... 2500 tons.

Making a total load on the foundation of ... 8500 tons.
Or the load which each of the 210 piles would have to support would be 40½ tons.

At this time (10 p.m.), Mr. George A. Parker, one of the committee, arrived and joined in the deliberations. The minutes were read for his information, and also such portions of the opening address of the presiding officer of the board—Mr. McAlpine—as related to the consideration of the subjects properly belonging to this committee, as follows:

"The bed of the river is a loose sand, which changes for a considerable depth with every stage of water, in freshets and during their subsidence, scouring out channels and making deposits. With the erection of the necessary piers of the bridge this scouring will be increased, and made it necessary to place these foundations below such possible future action. The rock lies at 28 ft. below low water at the west shore, and slopes towards the east, reaching a depth of 90 ft. at the last sounding two-thirds of the way across the river, which is nearly 2000 ft. wide. Some of the gentlemen will present plans of foundations requiring the use of iron pneumatic piles, which strike me very favourably, as meeting all of the requirements of the case—ample supporting power, facilities for rapid execution and comparative economy.

"If it should be concluded that these piles shall in all cases be driven to the rock, the grave question arises, can life be supported in six atmospheres at more than a hundred feet below the surface of the water? or will the knowledge and skill here present suggest some other practical plan for removing the interior sand and perhaps trees and boulders? and then will follow the difficulty of basing and securing the piles to the rock. When this is accomplished, these piles will become columns of support,

and you have to determine how much of their whole length may be deducted for the support of the sand around them, to give the proper co-efficient of strength from the ratio of length and diameter. The question will also present itself, whether a sufficient support can be obtained from these piles without forcing them to the rock where it lies at great depth. How much support will the area at the base afford, and can it be expanded, by using a bell-mouthed shoe, or by tunnelling after it has been sunk to any given depth? Again, how much support will the exterior cohesion on the piles give? (of course calculating only for that portion below any future possible scour, unless you decide that this scour can be replaced by masses of rock filled in, but out of the way of vessels which may pass close to the piers).

"Will these rocks silt up and give the same resistance and cohesion as the sand does below them?

"What will be the rate of corrosion of the iron piles under water? and can that corrosion be lessened or prevented?

"With what materials shall these piles be filled?

"How shall they be capped and spanned to enable them to carry the enormous weight of the masonry and superstructure, or shall the piles be extended up to the bridge seat, and can they be braced so that, together with their inherent stability, they will resist the impact of floating ice, drift, or vessels?

"You will also be presented with plans contemplating the use of an inverted caisson connected with a direct but removable one above it. This will require dredging to the depth of the possible scour, and probably curbing, and the subdivision of the inverted caisson and the use of the pneumatic process for filling it with masonry.

"Your attention will also be called to a plan for building stone piers based upon the rock, the details of which have been recently published in this city, and which will be laid before you.

"This published plan contemplates the use of three spans of about 500 ft. each.

"You will also be furnished with complete drawings of a bridge involving the use of two spans of 368 ft. each, and four spans of 264 ft. each for crossing the river with an iron bridge, and also of its approaches at its two ends.

"The law requires a bridge to be constructed with the alternative of one of its spans of not less than 500 ft. clear opening, or with two spans of not less than 350 ft.

"You will be called upon to consider whether the saving to be effected by the long spans in reducing the number of the piers will be equal to the increased expense of spans of such very great length, and whether suitable materials can be procured and put together so to sustain their own weight and that of stationary and passing loads.

"These and many other plans for the sub and superstructure will become the subject of your discussions, and, from the previous study which many of you, gentlemen, have already given to this subject, and the great amount of practical experience which you combine on all of the matters which will come before you, it is very certain that you will arrive at conclusions which will enable the capitalists here and elsewhere to determine with safety whether they will invest in the undertaking."

A résumé of the discussion, as far as it had progressed, was made.

Mr. Parker gave his views, which agreed generally with those expressed by the other members on the subjects that had been under consideration. Mr. Parker was then asked for some of the results of his experience in constructing the bridge across the Susquehanna, at Havre de Grace, where some of the piers were built in water 57 ft. in depth. A general idea was given of the management and position of this difficult undertaking.

The next subject considered was the action of floods and ice in the Mississippi, and their probable influence on the piers, and the general habit of the river above, at, and below St. Louis. This continued until a late hour, when the committee adjourned, to meet at 8 A.M., 22nd inst.

August 22.

Committee met at 8 A.M. Present—Messrs. Chesboro, Wm. J. McAlpine, Parker, Smith, and C. L. McAlpine.

The general subject of foundations was discussed for a short time by the members, when it was stated that the board having resolved to meet at 9 A.M. to receive such gentlemen and citizens of St. Louis as felt interested in the proposed bridge, or who had plans or suggestions to offer in regard to it, it was resolved without adjourning that the members of this committee should meet and accompany them to the river. On this excursion the members of the board examined the several locations which had been suggested for the bridge, and discussed their respective merits. While returning from this trip, Mr. Wm. J. McAlpine was called upon by the gentlemen assembled on the boat for a speech, during which he stated the object and purposes of the convocating here of so many of the leading engineers of the country. He said that the construction of a bridge at this place presented many interesting features to the engineer from their peculiar and unusual nature, and the magnitude of some of the difficulties which, at first, seemed to present themselves. Years ago such a project as this would scarcely have been entertained, but the world had progressed, and with it the science and skill of engineers. The profession would now undertake works confidently, that in former years would have been approached with hesitation. He saw here the leading engineers of the country, men who had already met and overcome many of the same kind of difficulties which would be found here, and they brought to the board the educated and practical science which could not be found in any of the text-books. In fact, the latter did not come down to the present time. The past quarter century had made such progress in this respect, and the engineering constructors had been so engrossed in the actual performance of great works, that the records of their skill and the description of the works they had accomplished still remained each with each, known only generally even to the other members of the profession; the invaluable details of difficulties met, only to be finally overcome, the ingenious and interesting inventions and devices, the results of the careful experiments, the knowledge gained of the laws of nature and the action of its great elements under peculiar and unusual circumstances, the plans that under certain circumstances will or will not answer the purpose, our failures as well our successes, the former being often as instructive as the latter, none of these can be

given to the intended constructors of this great work and the world in time to be of service here except in one way only, and that method has been fortunately adopted by the gentlemen who are projecting the construction of a bridge at this city.

The engineers, the men themselves, in default of their published records, have been brought together, and with a great amount of data in regard to the habit, regimen, position, &c., of the river at this place before them, they are to relate their experience, compare their methods, discuss their applicability, modify or combine such modes, and, finally, in full board to determine and present, for the benefit of the men whose money builds this work, the best and most judicious, safe and economical, skilful, scientific, and practical methods of accomplishing this purpose; and he assured the gentlemen, that in the whole course of his engineering life in this country he had never before had the pleasure of meeting so many of the great men of the profession assembled together at one time.

Heretofore it had been impossible to draw together so many of these busy men from their all-engrossing work, for no man but an engineer can know how thoroughly identified, as part and parcel of it, he becomes as his work progresses and develops, with new features, fresh developments, perhaps, new laws presenting themselves daily or hourly. They grapple with grand old nature, kindly, sometimes, in its disposition, at others frowning and forbidding; successes to encourage him, defeats to stimulate, nature's own laws and weapons in his hand to use against, or in conjunction, with his mighty opponent, until at last, the battle ended, he has added one more monument to the skill and triumphs of the present day.

Unsatisfied, however, with one success, he scarcely accomplishes it before he is eager to apply the valuable results of the school through which he has just passed to the other engineering works demanded of him by his fellow-men outside of the profession.

For purposes of profit and benefit to mankind, the present intelligent age asks of the engineer the best products of his brain, his skill, and his experience. Each work completed adds to his fund of knowledge, in turn to be made available for the use of those whose needs demand this information. In the case before us such wants have been felt, the men of science and practice have been applied to; and the latter, attracted irresistibly towards a project so interesting to the profession, have, with a unanimity heretofore unknown, laid aside or postponed their more immediate and pressing engagements, and with a harmony of feeling and a desire to learn from each other the results that have been accomplished by each in his own special works, and they are prepared to give to this project the advantage of their intelligent consideration. It can hardly be doubted that the results of their deliberations will combine all that is useful, skilful, judicious, safe, and economical in the construction of foundations at such depth below water, in a material of the character of this river bed, in the erection of piers of such magnitude, and, finally, in a superstructure of nearly an indestructible material which combines strength with comparative lightness, of a greater span than has ever before been attempted with trussed beams.

Mr. McAlpine here said that an apology was perhaps due to an audience like the present one, composed of many other professions and occupations, for confining his remarks so much to his own; but the nature of the occasion and his interest in the subject presented to them, necessarily made this address a repetition of many portions of that which he had presented to the convention on the day previous.

After the return of the party from the excursion, the committee met, and on motion Mr. McAlpine, as president of the convention, by the power delegated to him, was requested to add the name of A. Anderson to this committee, which was done, and Mr. Anderson took his seat as one of the committee.

General Smith was then requested to give the committee a description of the iron pneumatic pile process for forming foundations. The General said it would be necessary to first consider the nature of the material in which such a foundation was to be placed. From the information before the committee, it appeared that at a depth of about 30 ft. below low water a stratum of hard compact material was found. Whatever character of foundation reaches to and below this, and so gets beyond the reach of the dangerous scouring effect of the river, would seem generally to meet the requirements of the case. This scour has a limit. The velocity of the water usually diminishes rapidly in all deep streams from the surface to the bottom.

Mr. Homer has stated that in all his examinations he has found no sudden depressions or excavations in the bed of the river greater than 40 ft. below low water, neither alongside of any pier nor near any obstruction which may have been thrown into the stream. The greatest possible scour, therefore, may be considered safely within the limits agreed upon yesterday by this committee. The scour may possibly be reduced by the use of rip-rap.

Mr. Parker remarked at this point that the experience of Smeaton, at Hexham, should induce this committee to use great caution in the reception of the facts and data relating to the changeable bed of the Mississippi river, and that all the circumstances should be well weighed before they are relied upon. The bridge at Hexham was founded upon a bed of coarse gravel, but owing to peculiar circumstances it scoured out to such a degree that the foundations were undermined and the bridge was carried away—"almost the only mistake," said Mr. Parker, "made by this great father of the profession, and frankly acknowledged by him to be so."

A short discussion took place upon the use of rip-rap and other methods for preventing the scour from extending beyond reasonable limits.

General Smith said it will be admitted that a certain velocity or force of impact will carry off, or move, or disarrange rip-rap even when formed of the heaviest and largest blocks of stone, and instanced a case that occurred on Lake Michigan, on one of the Government works which he has in charge, where a lower timber of a crib filled with stone, becoming broken by the impact of the huge waves or surf—which continually struck it under high velocity—the stone inside of the crib was rapidly abstracted through the aperture and carried off into deep water. The crib was again filled, but the same result followed.

Mr. W. J. McAlpine also cited the well-known case at Oswego, where the shore of Lake Ontario is a smooth shelving rock, sloping gradually away into deep water. The Government engineers have at various times attempted to protect a long pier extending into the lake at right angles to the shore by heavy masses of rip-rap composed of slabs of stone from 10 ft. to 15 ft. in length, 2 ft. to 4 ft. in width, and 1 ft. and upwards in thickness. So strong has been the impact of the water upon these heavy masses, that they have been moved to a considerable distance, and their usefulness destroyed. The smooth sloping surface of the rocky bed of this portion of the lake, on an ascending and gradual rise from the deep water towards this structure—with less friction and few, if any, of the irregularities met with at other places—has the effect of concentrating the waval action with more than usual force upon the pier.

The problem of a proper protection for this pier is cited by the U. S. engineer as one of the most difficult within the range of their duties.

General Smith, resuming, said that, although under certain high velocities of water and peculiar circumstances, which made the instances named extreme cases, the employment of rip-rapping did not meet the requirements, yet this kind of protection against the effects of water in motion was too frequently used in places where it was serviceable to admit of neglecting its consideration as one of the aids towards securing the bottom of the river near the piers, and that if there was a certain velocity that would disturb this protection, there was also a certain less velocity at which the stone would not be much affected.

A discussion took place between the members in regard to the uses of fascines of loose brush, alternating with layers of stone, and Mr. McAlpine gave a description of the circumstances under which they were used on the State works in New York. Mr. McAlpine said that they had been used with very good results in many cases by the State engineers, in places where they had proved economical and useful—answering the purpose designed quite as well as any more costly methods. Its application to the proposed structure, in order to prevent scouring, was a subject which deserved attention; but that until the more complete data, which would be obtained after the actual commencement of this work, or at any other time before it was in the possession of the engineer, this method, as compared with any other, might be left for future consideration.

In this connexion Mr. W. J. McAlpine remarked that at the bridge over the Seine, built by Bassompierre, and recently examined by him in company with the engineer, he was informed that the entire width of the river under the bridge, and extending for some distance above and below it, was covered by concrete, which made a perfect protection of the bed of the river against scouring.

General Smith and the Messrs. McAlpine then gave a description of the process of sinking the pneumatic piles. The same general methods have been employed by Mr. Fleming on the Santee and Pedee rivers, by General Smith on the Savannah river, and by the Messrs. McAlpine on the Harlem river. The pile consists of a number of hollow cast-iron cylinders 6 ft. in diameter, 2 in. in thickness, and 9 ft. in length, provided with flanges on the inside by which they are bolted together, one on top of the other, until the desired length is obtained. The lower cylinder is clamped on the inside at the lower edge down to about a quarter-inch thickness. From a platform on temporary wooden piles or large scow boats a derrick is placed which suspends the column and lands it with the sharp end on the bottom of the river, in the place where it is to be driven. Another cylinder, called the air-lock, is placed on top of the column, usually made of boiler-iron sides of the same diameter as the columns, with a top and bottom plate of cast iron, in which are man-holes that can be closed at pleasure by plates with hinges opening on the lower sides and lined with rubber at the joints. In the top and in the diaphragm or lower plates are cocks, usually 2 in. in diameter. Leading from the outside of the air-lock, near the bottom, are two curved tubes 4 in. in diameter, which also pass through the diaphragm and are closed by cocks. The air-lock is bolted to the top of the column. Small air-pumps usually worked by a small steam-engine are connected with one of the curved pipes in the air-locks by means of a flexible 4 in. tube. The lower man-hole plate is then closed, and air is forced into the column. With the first stroke of the air-pumps the operation of compressing the air commences, and as this pressure increases it forces the water out through the open bottom. This continues until the pressure of air equals that due to the head of water outside the column, and the water has all been forced outside. The workmen then enter the air-lock and closing the upper man-hole a cock is opened in the lower diaphragm, and the compressed air from below is admitted. When the pressure has become equalised the lower man-hole plate falls, and the workmen can pass down on ladders to the bed of the river to excavate the material, which is raised in canvas bags to the air-lock by means of a drum, the shaft of which passes through stuffing-boxes to the outside, where it is worked by hand on signal. When the column has been entirely cleared down to the bottom, care is taken to see that no obstructions, such as boulders, logs, &c., remain under the rim of the column.

The workmen ascend into the air-lock, and, closing the lower, the compressed air in the air-lock is allowed to escape through a cock in the upper plate. When the air in the air-lock has become equalised with the atmosphere, the upper valve falls, the men pass out, and the bags of material are removed. Men are then stationed at the guy ropes, and the 4 in. cock in the curved pipe is opened, and the compressed air in the column allowed to escape quickly. The upward pressure of the air in the column on a surface 6 ft. in diameter neutralises the weight to an extent which is governed by the depth of the bottom of the column below the surface of water. By allowing the air to escape quickly in the manner mentioned, this weight is suddenly restored with an effect similar to a blow, while at the same time the rapid inrush of water at the bottom causes a complete scouring of the material at and under the sharp rim of the column, and the resistance to driving the column is simultaneously removed.

The friction of the outside of the column against the material through which it penetrates is greatly diminished by the current

of water passing along its surface from the river on its way to the inside. If no rocks, trees, or similar obstructions are encountered, the column will continue to settle quite rapidly during the time the air is escaping, and afterwards until the material has stopped scouring under the edges, and has compacted itself under the pressure of the water sufficiently hard to sustain its weight. The amount of settling in one operation will frequently amount to 10 ft. or 12 ft., or even more.

When boulders or logs are met with the column stops, and it is then recharged with air. The workmen descend and remove the obstruction, and the process already described is repeated. In this manner, columns of almost any dimension may be sunk to any required depth. The above is given merely as the main governing principle and method that have been used in sinking these piles, but they are capable of great modification in size, shape, and material, and are adaptable to the various requirements of different localities, their merits appearing in the most striking manner in situations where almost any other plans in use become costly, difficult, and hazardous. Their firmness under heavy loads or shocks by impact of water, vessels, ice, &c., is remarkable. Mr. Fleming, at the Pedee river, had one pile, which had only then penetrated 8 ft. into the sandy bottom, and which sustained during a freshet a jam of logs and drift-wood extending from the pile for a quarter of a mile up the river.

Mr. McAlpine instanced the blow of a steamer, coming down with the tide, striking full against a column in the Harlem river, which was unsupported by any bracing, without doing the slightest damage or causing any movement.

It may be safely taken, then, that these columns will resist any shocks, particularly when braced against each other, and filled with concrete masonry, or other material, almost equal in extent to the actual crushing force of the cast iron. General Smith recommended that, without using the air pressure, a sand pump in open cylinder be used for excavating the inside of the pile when containing sand, or other material, which is made semi-fluid in water. The air-lock may be placed on the column, and the air pressure used whenever a different material is met with, or when boulders, stumps, or logs arrest the downward course of the pile.

When working in sand alone, piles have been sunk at the rate of 20 ft. to 25 ft. in six hours. General Smith prefers piles of 8 ft. in diameter, as he can settle them more rapidly, and they furnish more convenient working room. If these piles are used for the proposed bridge, they can be sunk to such a depth, if necessary, that the iron would crush before the pile could be forced deeper by weight imposed upon it.

Mr. Parker raised the question whether the piles could be relied on to sustain the pier, if the scouring took place to a depth reaching nearly to their lower extremity.

All of the members agreed at once that they would not, because much of their supporting power depends upon the adhesion to the sides of the column of the material through which it penetrates.

Mr. W. J. McAlpine mentioned that he had increased the supporting power of the bottom of the pneumatic piles at Harlem by expanding it to three times the area of the true column; this was done by excavating outwards, more than 2 ft. beyond the circumference of the pile, and filling in for an extra depth of 3 ft. with a solid mass of concrete—and that this principle was capable of greater extension by the use of suitable iron roof piling.

All the members of the committee agreed that there was no doubt that abundant supporting power could be readily obtained by this process, and that the firmness of a group of piles, as proposed, properly braced, would be amply sufficient to resist the shocks of ice, vessels, &c.

Mr. W. J. McAlpine and General Smith both recommended that if this plan was found most advisable, that, instead of stopping the columns at the level of the scour line, and building piers of masonry upon them, that the columns should be carried up 85 ft. above low water to the level of the bridge seat, as imposing less weight on the foundations, and being far less costly than the use of masonry.

General Smith also recommended for consideration that, instead of iron piles wooden columns, square in section, larger at bottom than at top, shod at bottom with cast iron, and loaded to resist the upward tendency of the compressed air, should be used below water, and that, after these columns had been sunk to the required depth, they should be filled in with concrete or other masonry.

Mr. Parker stated that, when it became necessary to build the bridge across the Susquehanna at Havre de Grace, the expediency of using pneumatic piles was considered, but he was deterred from their use, owing to the peculiar features of that particular case. He said that the piers of Brunel's bridge across the Saltash were built in 50 ft. depth of water, and the excavation below this to the rock was from 30 ft. to 40 ft. besides. Brunel thought that grouped pneumatic piles at this place were not as suitable as a large caisson, built and worked on the pneumatic principle, and subdivided into compartments; this caisson was sunk to the bottom, and the masonry built inside of it, under air pressure. At this depth, 80 ft. to 90 ft. below surface of water, great difficulties and risks were encountered, but the plan was finally successful. Three years were occupied in constructing this work, which was considered by the committee as very slow progress. This plan was not found to be suitable at Havre de Grace for several controlling reasons, and he was obliged to consider others. He was almost doubtful, indeed, if his piers could have been built at some of the places within reasonable cost and hazard by any other than the method adopted. This was at places where the water was very deep and swift currents running, with a velocity at times of twelve miles per hour; the river also was very broad, in fact, being the northern extremity of the Chesapeake Bay, and liable to storms in which small boats could not live, and was very dangerous for large ones. It was found impossible to excavate the material in all cases down to the rock. Wooden piles were driven at some of these places, and left for a time that the action of the currents might be observed, when it was found that scouring took place about the piles to such a degree that their usefulness was destroyed. This scouring effect, however, aided the plan that was finally adopted by assisting in the removal of the material which overlaid the bed rock.

It of course became impossible to place piers on piles in this condition, and that plan was given up. The expediency of using coffer-dams had been considered, but they could not be adopted with safety, owing to the peculiar circumstances of the case already named. The deepest coffer-dam used on the Thames was 21 ft. below low water. The tides on this river are sometimes as great as 30 ft. He was strongly in favour, at one time, of using the pneumatic piles.

Mr. Parker then gave a description of the mode finally adopted by him. He stated that each of the nine piers required a different treatment—the circumstances in no two being alike—but the general plan was first to dredge away as much as possible of the material in the bed of the river at the pier site. A three-eighths inch thicker boiler-iron curb was then sunk and secured in its place. The curb was about 30 ft. wide and 50 ft. to 60 ft. long, and of sufficient height to reach above the bed of the river.

A tell-tale framework of light timber attached to the curb, and reaching from it to above the surface of the water, told always the position, inclination, and place of the curb. Sand pumps were then used and the material pumped out of the curb, which gradually undermined and settled down to the required depth, or on to the bed rock. When stumps, logs, or boulders were met with, they were removed by divers working in a bell. After the rock had been thoroughly cleaned off, it was brought to a uniform level by a solid bed of concrete extending over a greater space than the size of the bottom of the pier, using the diving-bell for this purpose. Sometimes there would be a heavy sea which interfered greatly with the operations.

The water in some places was 38 ft. deep, and this was increased to 58 ft. by the excavation.

Three guide piles on each side, and one at each end, were fixed firmly in position. A strong platform of solid timber, the size of the bottom of the pier, was then placed in position over the curb, and at the surface of the water. On this is placed a caisson of iron large enough to contain the pier, and with sides and ends high enough to reach to the level of high water after the caisson is landed on the bottom. When this caisson is made water-tight, the bottom was then floored over with masonry and stone, and laid in mortar up the sides of the caisson to the top, thus constituting a stone caisson inside of an iron one. This is secured to the guide piles and the masonry of the pier proper is laid up, the caisson sinking as the weight of masonry inside increases until it finally settles upon the bottom, which has been prepared for it, as already described. It is found necessary to brace this caisson strongly to resist the collapsing pressure of the water on the outside, which, at a depth of 46 ft., equals nearly one and a half tons on each square foot. The work is done easily and secured inside the caisson, and it usually occupied only from three to four days to finish the masonry to above the level of the surface of water. At some of the piers screw rods were used to suspend the pier and gearing attached governed by one man who at pleasure could raise or lower without assistance the whole pier. In one case it became necessary to relay some of the top courses, and one man raised the pier as high as 10 ft. The rock was reached and the masonry founded upon it at five of the piers. At the other four, after the dredging had been finished, and the curb was sunk to the required depth, wooden piles were driven, and cut off under water by machinery just above the ground, and the platform, with its incumbent pier, lowered upon them.

The plan described is a suggestion to be considered as to its adaptation to the foundations of the St. Louis bridge; but Mr. Parker might vary and modify his opinion as circumstances and further data and discussion might suggest. He would advise basing the foundation piles on the rock, when it is not at unreasonable depth below the bed of the river.

A partial *résumé* of the subjects that had been under discussion was had, and it was determined to ascertain and embody in a resolution the conclusions at which the members had severally arrived up to this point.

Resolved, That in the opinion of this committee it is both safe and practicable to construct a bridge at St. Louis, of the character of the one which we have had under discussion, with the piers first placed upon foundations of hollow iron piles driven on the purely pneumatic principle, either to the rock or, when it lies at too great depth, by an expansion of their base, or driven by the use of sand or steam syphon pumps; 2, or both of piers of masonry carried below the scour of the river by the use of iron caissons, as was practised at the different piers of the Susquehanna bridge, and resting on either wooden piles or small pneumatic piles; or 3, by the use of a combination of inverted and direct wood or iron caissons, the inverted caisson filled with masonry by the pneumatic process, and the direct caisson in the ordinary way; and 4, with piers laid up either of solid or galvanized masonry; or 5, with the iron pneumatic piles extended upwards to the bridge seat as columns of support, and strongly braced on the lines of the river and the axis of the bridge.

The committee, at this period of the discussion, refrain from expressing their preference in favour of either of the above plans, until further careful estimates have been made upon each, to show their comparative economy, stability, and facility of execution.

On motion the committee adjourned to meet on August 22, when they met pursuant to adjournment.

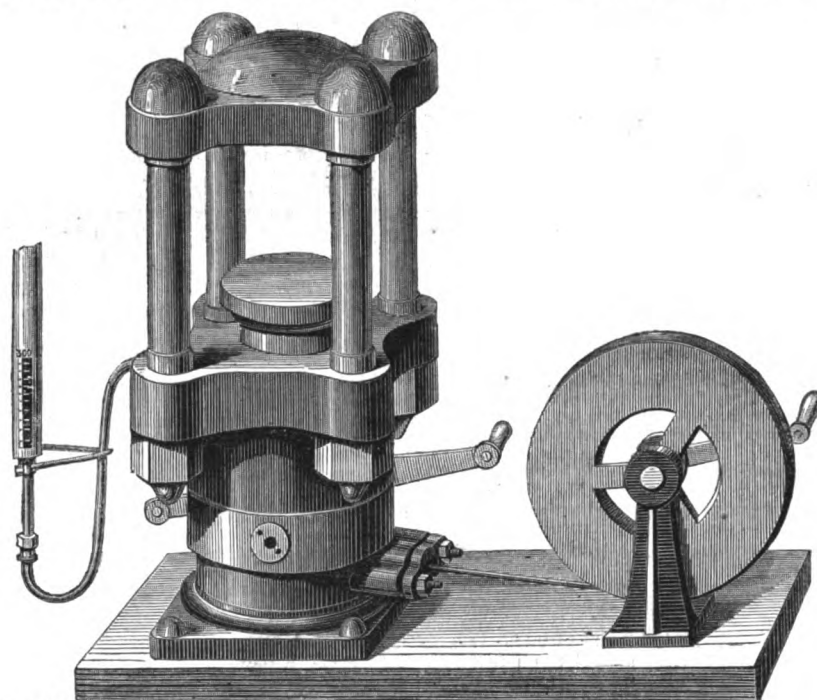
The further consideration of the questions involved in the construction of the proposed bridge require consultation between the Committee on the Regimen of the River, and that on Superstructure, in order that some of the general points affecting the calculations of each of the committees might be agreed upon. A conference was therefore had with the two committees named, and a joint meeting was held to consider these points, consisting of the following named gentlemen:

T. J. Homer, J. B. Moulton, H. C. Moore, E. S. Chesboro, W. S. Smith, Geo. A. Parker, L. J. Fleming, A. Anderson, C. L. McAlpine, S. S. Post, R. M. Shoemaker, G. Chanute, T. B. Blackstone, W. J. McAlpine.

The chairman of the Committee on Superstructure having made elaborate drawings, estimates, and descriptions of plans, and having placed them all before the joint committee, the members thereof proceeded to discuss the general subjects and to compare the results of other experiences applicable to the

HYDRAULIC PRESS AT THE PARIS EXHIBITION.

CONSTRUCTED BY MESSRS. DESGOFFE AND OLLIVER, ENGINEERS, PARIS.



HYDRAULIC PRESS.

case so far as to satisfy themselves that the calculations, &c., referred were substantially correct, and sufficient to enable them to proceed with the further general consideration of the questions involved, which were presented by Mr. McAlpine, as follows:

1st. Of the two alternatives for the spans for the main channels allowed by law, which should be adopted?

2nd. What spans (within the limits of the law) are the best for the remainder of the distance?

3rd. What dimensions and accommodations of bridge are necessary for the convenience of its traffic?

4th. What will be the approximate cost on the basis which shall be decided, in reply to the foregoing propositions?

In response to the foregoing questions the committee, after due deliberation, passed a series of resolutions embodying their conclusions upon the points involved. Those resolutions will be given to the public in the general report, which will be published shortly.

NEW FORT AT PLYMOUTH.

THE foundation of the Shovel Rock Fort, as it has been hitherto called, inside the breakwater, at Plymouth, having been completed some two or three years since by the Admiralty, was then passed into the control of the War Department, whose proper office is, it appears, to erect all that portion of the fortification which is above high-water mark. It appears that the War Office has at length determined to commence operations. The breakwater is built nearly east and west, and underneath the eastern part, lying nearly north and south, is the Shovel Rock. It is upon the inner or northern portion of this rock, separate from the breakwater, that the foundation is laid. The lower part of the foundation consists of granite blocks and cement and concrete blocks faced also with granite; the inner portion is filled in with cement concrete blocks brought up to high-water mark in one solid and compact foundation. Upon this the basement is built, the sill of the casemates being about 16 ft. above high-water mark. The inner, or north, side of the basement will contain the magazines, and the sea, or south, side will be fitted up as abutment-rooms and accommodation for men. From this basement communication will be had by two circular staircases of stone to the casemates over. We now come to a description of the new work. Hitherto this erection has been called the Shovel Rock Fort; hereafter it will be termed the Breakwater Fort. Although close to it, the breakwater is unconnected with it, and there appears no present intention of forming a connexion. The foundation is oval; the fort will be the same, and will extend to within 4 ft. of the verge. The masonry basement is 150 ft. east and west by 120 ft. north and south. The casemates will be above 45 ft. deep, leaving open in the centre a space some 50 ft. by 30 ft. The battery will mount eighteen guns, which will be nearly equidistant from each other, and will point in all directions. The face of the battery is to be 11 ft. high, with a rake, like a ship's side, of 18 in.; it will consist of three layers of 5 in. wrought-iron plates, bolted against perpendicular wrought-iron ribs, about 3 ft. apart. Three feet behind the ribs there will be at intervals some wrought-iron cylinders filled with the best concrete. They are to be 7 ft. by 3 ft., with the broadest part facing the ribs. The roof of the casemates will consist of arches of brick covered with concrete 6 ft. thick, and faced with Seyssel asphalt to keep the casemates dry. The accommodation for artillerymen is not very extensive; but it is contemplated that, during peace at least, it will not be necessary for many to be stationed there. It is understood that Messrs. Hubbard, who have had several contracts at Plymouth from the Government, will erect the Breakwater Fort.—*Times*.

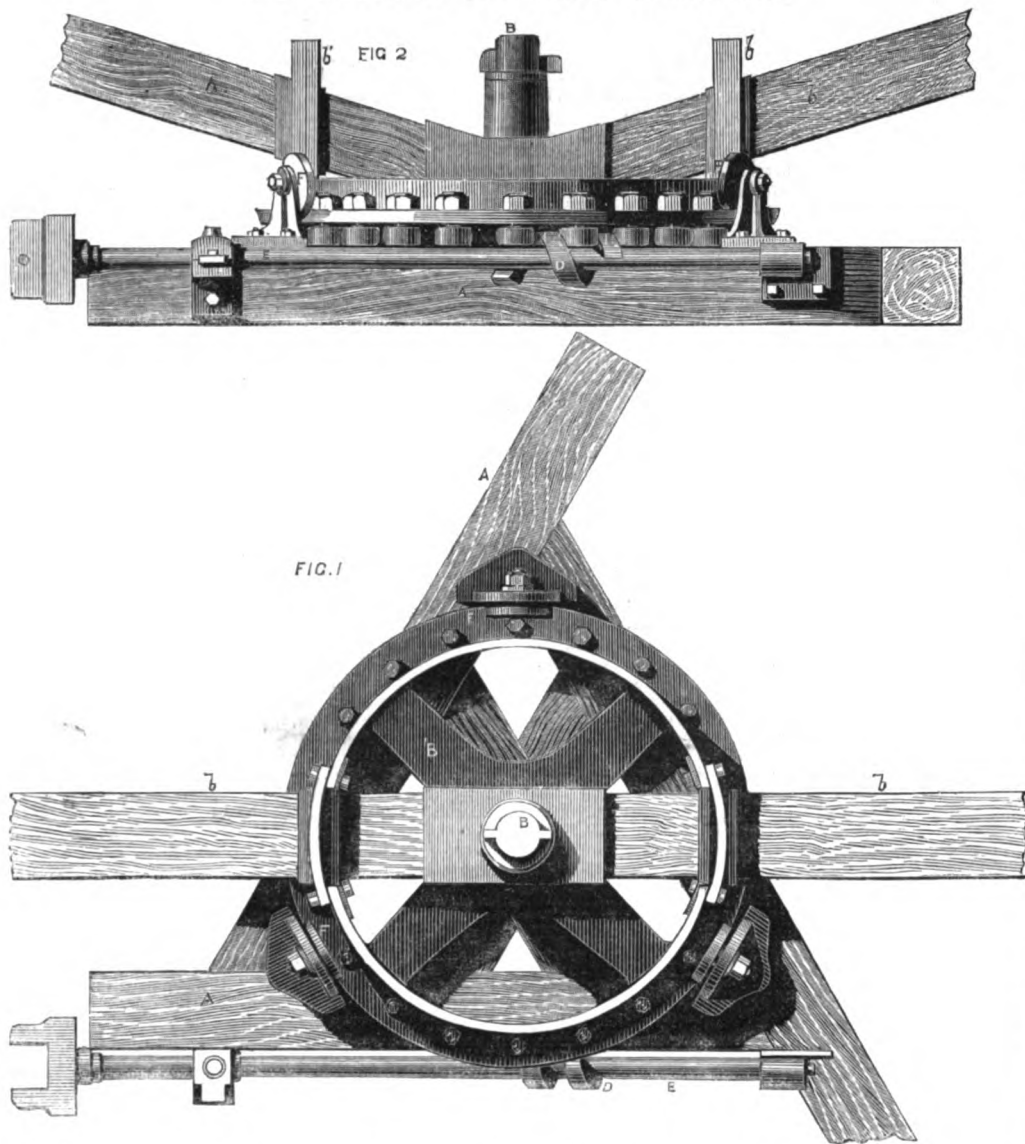
THE GREAT INDIAN PENINSULAR RAILWAY.—The Government of Bombay has called for an immediate report on the general state of the viaducts of the Great Indian Peninsular Railway.

MESSRS. DESGOFFE AND OLLIVER, of Paris, are successful makers of machinery and apparatus for measuring strains, testing iron, &c., and they have supplied sets of testing-machines to the Conservatoire des Arts et Métiers, and to some of the imperial arsenals and factories. The machines exhibited at Paris by these makers show that they generally limit each machine to the performance of one kind of tests only, instead of enabling one machine to submit the articles operated upon to a variety of trials, such as is the general practice in England, and is certainly the preferable plan, from a variety of reasons. Amongst the machines shown by Messrs. Desgoffe and Olliver at Paris, we notice a hydrostatic press, with a peculiar arrangement for the transmission of force to the ram which presents some originality, although it is difficult to say at once whether the plan will be found advantageous in practice. The hydraulic press cylinder contains at its bottom a horizontal spindle, round which a thin gut cord is coiled, and this cord passes out through the side of the cylinder, packed by a leather or other stuffing, and is coiled round a small drum or pulley standing close by the press. The spindle within the cylinder passes out through a stuffing-box, and carries a crank-handle outside, and by turning this handle the cord can be uncoiled from the pulley and drawn into the press-cylinder, where it coils round the spindle. The cord drawn into the cylinder displaces the water within, and causes it to raise the ram with a power corresponding to the proportion of the area of the ram, and the area of cross section of the cord. The operation of raising the ram of this press consists, therefore, in turning the handle at the press-cylinder, while the return stroke is effected by turning the other handle connected with the pulley outside, and thereby withdrawing the cord from the cylinder, and coiling it round the outer drum. For a quick return motion water may be allowed to escape from the press-cylinder, and afterwards re-supplied when the cord is uncoiled; but a proportionately quick return stroke is provided for in the arrangement itself, the diameter of the outer drum being much larger than that of the spindle within the cylinder, so that one revolution of the crank in the return stroke is equivalent to a considerable number of turns of the other handle, through which the pressure is exerted. The liquid used by preference in the press cylinder is oil, and the principal application of such presses, besides testing the strength of materials, is for forcing railway wheels on and off their axles, for which purpose such presses are said to be in use in several establishments in France. The exhibitors also state that the cord can be made of a diminishing thickness without interfering with the efficiency of the packing in the stuffing-box, so that a gradually increasing strain may be obtained at any desired stage of the operation, the application of force at the handle remaining constant.

CEMENT FOR PATENT FUEL.—One of the best cements for the agglomeration of coal-dust and the manufacture of "patent fuel," is that used in several Continental establishments, consisting of coal-tar, gluten, and starch. The quantities of these substances are altered according to the quality and properties of the coal-dust; but they are very easily ascertained by a few experiments. About 2 per cent. of this mixture (say, containing $\frac{2}{3}$ parts of coal-tar, $\frac{1}{3}$ part of gluten, and $\frac{1}{3}$ part of starch) would be suitable for coal-dust of an average quality of bituminous coal.

CORNISH PUMPING-ENGINES.—The number of Cornish engines reported for the past month is twenty-three, which consumed 1477 tons of coal, and lifted 11.5 million tons of water 10 fathoms high. The following engines exceeded the average duty of 52,600,000 lb., lifted 1 ft. high by the consumption: 112 lb. of coal: Chiverton, Cargoll, Chiverton Moor, Cook's Kitchen, Great North Downs, Great Work, North Rook, Providence, South Wheel Frances, West Chiverton, West Wheel Seton, and Wheel Seton.

JENSEN'S HORSE-WHEEL.



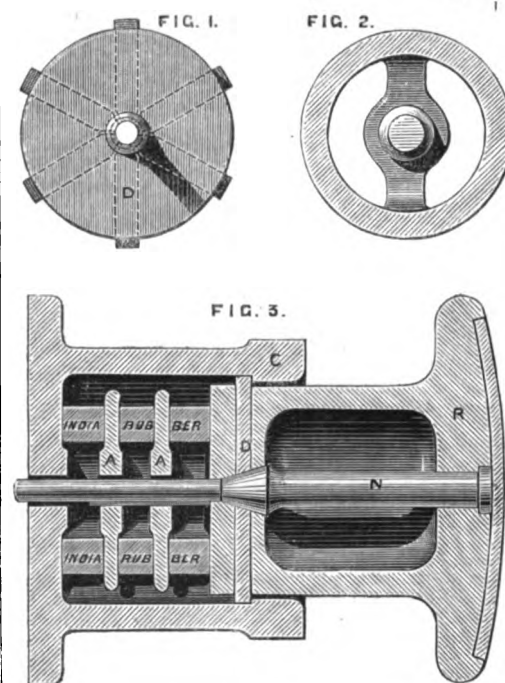
We give, above, engravings of a horse gear or horse-wheel, designed and recently patented by Mr. Peter Jensen, the novelty of the arrangement consisting in the means employed to transmit the motion from the wheel driven by the horses to the shafting leading to the machines to be driven. In the illustrations, Fig. 1 is an elevation, and Fig. 2 a plan, of the arrangement, and from these its construction will be readily understood. A, is a wooden framed bed to which the various stationary parts of the machine are attached, this frame carrying the upright pivot, B, on which the wheel, B', revolves freely. On the pivot, B, is also placed a boss having a couple of sockets in which the ends of the horse-poles, *b b'*, fit, these poles being connected to the wheel by the staples, *b' b'*. In the rim of the wheel are placed, at equal distances, a number of pins, each carrying a roller which revolves freely on it; these roller pins being at right angles to the plane of the wheel, or parallel to its axis. The rollers just mentioned form a substitute for the teeth of ordinary wheels, and they gear into a wrought-iron worm, D, formed on the spindle, E, which is carried by bearings on the main frame. To prevent any springing of the rim of the wheel, which may be made very light, three rollers, F, are arranged to bear against its upper side.

The horse-wheel above described works very freely, and is stated to yield a greater percentage of useful effect when tested by the dynamometer than the ordinary horse-wheels. It also works very smoothly, and a lengthened trial in actual work shows the arrangement to be durable. Mr. Jensen also proposes to use this arrangement of roller and worm gearing for various other purposes, the rollers being fitted either to wheels or to a bar, so as to form a rack. A "roller-rack" of this kind driving a worm forms a convenient mode of converting a reciprocating into an oscillating or alternating rotary motion, and there are many occasions on which it could be advantageously employed. The "roller-wheel" and worm, arranged as in the horse-wheel, form a substitute for bevel gearing; and Mr. Jensen states that they work with less friction than a bevel wheel and pinion constructed so as to increase the speed in the same ratio.

ANGUS'S BUFFER-PLUNGER FASTENING.

We annex an engraving showing a method of securing the plungers of railway buffers, which is adopted by Mr. Robert Angus, the locomotive superintendent of the North Staffordshire Railway, who designed the plan about ten years ago. The object of this mode of fastening is to remove the strain from the central bolt, and thus prevent the fracture of the latter, so often caused by the sudden recoil of the buffers. This end is obtained as follows: The plunger of the buffer has a number of radial

slots formed in it near its inner end, and in these slots are placed sliding pieces, D, which, when pressed outwards, project



beyond the circumference of the plunger, and catch against a lip or rim formed in the interior of the casing, C. The forcing outwards of the sliding pieces is effected, after the plunger is in its place, by means of the bolt, N, which is made with a conical collar at that part which passes through the bottom of the plunger. The bolt is secured by a plate put over its head. The plan is very simple, and forms a very secure fastening for the plunger. Our engraving of this buffer-fastening has been prepared from a tracing for which we are indebted to Mr. Angus;

THE SIEMENS PROCESS.

ALTHOUGH the new mode of steel manufacture recently patented by Mr. C. W. Siemens has not as yet obtained a commercial standing or importance, it is attracting considerable attention on the part of metallurgists in this country and abroad. The Siemens process consists in reducing the iron from its ores by the action of gases containing a surplus of carbon, and elevated to a high temperature by the combustion of a part of these gases. It is, in fact, the action of a reductive flame, such as used very frequently in metallurgical operations on a large scale, or such as can be produced on a small scale by means of the blowpipe. This flame deprives the metal of the oxygen and other elements combined with it in the ore, and brings it down in a molten state, as cast iron if charged sufficiently with carbon and tapped at a low temperature, or as steel if the proportion of carbon to smaller, and the temperature of the furnace sufficiently high for keeping this steel in a liquid state. The process in its abstract and theoretical *rationale* is one of great scientific beauty. It attempts to treat with the materials in the most direct manner, avoiding all the different makeshifts and imperfections which are included in the present practice of iron-smelting. In its practical development, the Siemens process has not as yet passed its infancy. Experiments have been made by Mr. Siemens in his model steel works at Birmingham apparently on a very small scale, and a small piece of steel made by his process is exhibited at Paris. The Barrow Steel Works have commenced experimenting on a much larger scale, a furnace which, according to present notions, may be considered a full-size specimen for practical work, having been erected in these steel works, and some charges of hematite ore having been smelted or reduced into steel in this furnace. Some ingots are said to have been produced, but the facts relating to the manner of working, and the lessons drawn from these first experiments, cannot be published yet. The furnace, we understand, is now about to be altered, and further experiments will be made with it shortly. At the recent visit of the guests of the Furness Railway Company to the Barrow Steel Works, this new furnace, although not in operation, and so far under reconstruction that very little of its internal arrangement remained visible, seemed to be regarded as an object of great interest by several visitors.

The question naturally arises, what are the practical advantages to be expected from this new process? but this cannot be answered otherwise than in very general terms at this early date. It is likely that the production of steel by the Siemens process will require less carbon than the present mode of first over-carburising the iron, and then decarburising it by a special and second process. It is also clear that the application of gaseous fuel will make the quality of iron much less dependent upon the quality of the fuel, since the very worst kinds of fuel can be made suitable for smelting by generating gases, and purifying the latter before they come in contact with the ore. The formation of a suitable slag in the process of smelting will, in an equal degree, lose its importance, since the iron in the Siemens furnace does not require a similar protection against any oxidising influence, as is the case in the blast furnace in front of the tuyeres. The only condition which seems to come out more prominently and more forcibly in the Siemens process than in the present practice of iron-smelting and steel-making is purity of the ore. This, however, seems to become more and more a primary condition with iron-smelting in its present form, and will not, by itself, interfere with the prospects of success of the new process, if all the other necessary conditions will be fulfilled in a sufficiently practical manner.

THE CLEVELAND IRON TRADE.—The home deliveries of pig iron from the Cleveland district have been rather larger of late. The Continental demand is dull, being checked by expectations of a monetary crisis in France, coupled with the want of confidence which exists to a large extent on the Continent. There is a little better inquiry for pipes and castings, the latter including railway chairs. Founders complain that prices are low, but they are not disposed to have the orders taken out of the district, and they are for the most part successful in securing work. A further order for chairs for the East has been received. Inquiries for rails for home and the Continent are still going forward, and some of the large masters are said to have taken orders to a sufficient extent to keep their mills going during the winter months.

Messrs. BOLCKOW, VAUGHAN, AND CO. (LIMITED).—This company raised last year from its Estou mines 710,000 tons of ironstone. The extraction of coal from the collieries of the company also amounted to 1,000,000 tons. The quantity of pig iron made last year was about 200,000 tons; and of iron, 80,000 tons.

TUNNELLING AND MINING BY MACHINERY.*

By HERMAN HAUPT, Civil Engineer, U.S.

At no former period in the history of mining and tunnelling enterprises has the attention of engineers in all parts of the world been so generally directed to the necessity of providing mechanical appliances to supersede the tardy and expensive hand labour heretofore universally employed, and never before has such a diversity of machines to facilitate subterranean operations been presented to the public.

The necessity of employing machinery to expedite the operations of tunnelling appears to have been first recognised by the Chevalier Manns, who, many years ago, boldly avowed his belief in the practicability of tunnelling the Alps, and proposed to accomplish this stupendous work by cutting grooves or channels in the rock, forming prismatic blocks, which he supposed could be easily removed by wedges. The power was to be transmitted by means of endless straps supported upon rollers in the same manner in which inclined planes are usually operated.

This suggestion was not practically carried into effect, and subsequently the plans of M. Sommelier and his associates were adopted, giving to the world an actual demonstration of the fact that mechanical appliances could be made available to reduce the time if not the cost of tunnelling.

The first public experiment made by M. Sommelier was in 1857, previous to which time the writer, who had undertaken a similar work of tunnelling the Hoosac Mountain, in Massachusetts, by a tunnel five miles long, passing 1750 ft. below the summit, had commenced an independent course of investigation and experiment with a view to construct some apparatus by means of which the work could be facilitated, and it is to the results of these labours, extended over a period of years, that attention is now more particularly directed.

Previous attempts had been made to use machinery for tunnelling the Hoosac. About the year 1852 an enormous machine was constructed and actually put in operation at the eastern portal of the tunnel, which was designed to cut a groove 13 in. wide around the circumference of a circle 24 ft. in diameter. The cost of the machine was about \$45,000. It consisted of a portion of an iron cylinder 23 ft. in diameter, on the periphery of which cutters were placed, some projecting inwards and some outwards, like the cutters in the diamond drill of Leschot. The cutters consisted of steel discs about 15 in. in diameter, which were pressed against the face of the rock, and as the cylinder was rotated and fed forward, the rock was ground away. The machine cut its way into the talcose slate of the mountain about 25 ft. or 30 ft., but the experiment was not a success. Although the amount of work to be performed in cutting a groove 13 in. wide was much less than would have been required in cutting or grinding off the whole area, yet the strain upon the machine was excessive, and it is obvious that great difficulty must have been experienced in regulating the feed in proportion to the ability to penetrate the rock, and also in advancing and withdrawing the machine.

Although the parties who constructed this machine were rendered insolvent by its want of success, yet this fact did not deter others from an expenditure of \$25,000 in the construction of a smaller machine, in which an attempt was made to bore a heading 8 ft. in diameter, to be subsequently enlarged by hand labour.

The second machine was designed to operate on the same principle as the first, except that the whole area of the circle, instead of a ring of moderate thickness, was to be ground off by means of the circular cutter. In both of these machines steam was to be the motive power, but there does not appear to have been any clear idea of the manner in which steam was to be generated or applied.

Only a single trial was made of the second machine, and with no very satisfactory results, when it was abandoned, and subsequently both machines were sold for old iron.

The principle of the rotating-discs for cutting stone, although the attempt to apply it to tunnelling in America had not been successful, was nevertheless used in the construction of machines for dressing sand-stone, and in 1854 a number of machines were used in the city of New York for this purpose. These machines consisted of shafts slightly inclined forward from the vertical, and carrying at their lower extremities arms which supported the discs. In each machine the stone was placed upon a carriage and fed forward in a manner similar to the feed of a log upon a saw-mill. The stone was chipped off, and the surface left in good condition. It does not appear that these machines were used for dressing very hard stone, and even for soft stone their use does not seem to have effected any very considerable saving, as they are not at present known to be in use.

In 1856 the direction of operations at the Hoosac tunnel fell into the hands of the writer, who, having no faith in the larger machines previously described, directed his attention to the discovery of the best form of engine for drilling holes of the ordinary size to be blasted by powder, and also to the consideration of the most expeditious and practical modes of erecting and removing the machines, and the most economical and efficient means of applying power and securing ventilation. The results of these investigations were given to the public in a pamphlet published by Messrs. Blanchard and McKean, of No. 3, Rue Scribe, Paris, in which the construction and operation of the drilling-engines, and the subjects of power and ventilation are discussed at length.

Requirements of a Drilling-engine for boring Rock.

A drilling-engine for perforating rock requires three movements:

1. A reciprocating movement.
2. A rotative movement.
3. A feed movement.

The Reciprocating Movement.

The reciprocating movement in nearly all drilling-engines is produced by the to and fro motion of the piston. The points to be determined in connexion with this movement are the diameter and stroke of the cylinder and the form of valve.

* Paper read before the British Association at Dundee.

If the drilling-tool is connected with the piston, and the blow upon the rock is given by the action of the air or steam, the pressure per square inch being assumed, the diameter of cylinder necessary to secure any given total pressure is readily determined; a diameter of cylinder of $4\frac{1}{2}$ in., with a piston-rod of $2\frac{1}{2}$ in., will leave an annular ring of $9\frac{1}{4}$ square inches for the power to act upon; a pressure of 60 lb. per square inch will give a total force upon the piston of 560 lb., and this is found to be sufficient to strike a blow as hard as the steel used in the drill points can stand.

The force of the blow is almost entirely independent of the length of stroke, and it therefore follows that the stroke should be as short as will fulfil the other essential conditions of moving the valve, rotating, and feeding. For these purposes 4 in. is found to be a convenient length, and the capacity of the cylinder is determined to $4\frac{1}{2}$ in. diameter, and 4 in. stroke, allowing a breadth of piston of $2\frac{1}{2}$ in. and a small space for clearance at the end, the inside length of cylinder is about 8 in. Drills constructed with larger cylinders involve an unnecessary waste of power. At each stroke two cylinders of steam or air must be expended. The travel of a piston per minute should not exceed a given number of feet, whether the stroke be long or short, consequently any increase in the length of stroke must diminish the number of blows per minute with a given velocity of piston.

Assuming 250 ft. per minute as the proper velocity of piston, the travel at each stroke will be 8 in., and the number of blows per minute 375. If a stroke of 10 in. should be given, as in several drills that have been constructed, the number of strokes with the same velocity of piston would be reduced to 150 per minute.

The expenditure of steam or air at each stroke is 94 cubic inches, and per minute 20 cubic feet.

With 300 strokes per minute, and the area of the forward end of the piston reduced to 6 square inches, the consumption of air or steam per minute would be but 14 cubic feet.

At 60 lb. per square inch in addition to the pressure of the atmosphere, the temperature of steam would be 311° Fahrenheit, the volume as compared with water as 383 to 1, and consequently the quantity of water to be evaporated per hour for each drill would be three and thirteen one-hundredths cubic feet.

As one cubic foot of water evaporated per hour is required for one horse power, the boiler or reservoir capacity must be sufficient to furnish three and thirteen one-hundredths horse power for each drill.

Estimating the actual power upon the piston as 560 lb. travelling over a space of 250 ft. per minute, the performance of the drill engine would be equivalent to 140,000 lb. raised one foot, or about four and one-quarter horse power.

If the stroke should be 10 in. instead of 4 in., and the number of strokes per minute be supposed the same, the actual effect would not be increased, but the expenditure of steam or air would be seven and eighty-two one-hundredths cubic feet per hour, or nearly eight horse power.

The propriety of a short stroke must therefore be apparent.

Valve.

For ordinary crank-engines, the slide-valve is well adapted, but for drilling-engines the ordinary form is seriously objectionable. Whatever may be the mode of connexion between the piston-rod and valve, the opening into the cylinder must be by a gradual sliding movement, which opens the port for the admission of air or steam into the forward end of the cylinder before the stroke is fully completed, and the blow given upon the rock. It is obvious, therefore, that the steam or air is entering and retarding the velocity of the piston at the very point where it should be greatest. If under these circumstances a blow is given of sufficient force to be effective, it must be secured by a wasteful expenditure of power to compensate for the retardation caused by the slide-valve.

The valve which has given most satisfactory results is nothing more than a piece of pipe, on which four rings are shrunk and accurately turned to fit the cylindrical steam-chest in which it moves; the two middle rings open and close the ports precisely as in a slide-valve when its position is shifted.

If this valve had a rigid connexion with the piston-rod, it would be a balanced slide-valve moving with very little friction, but possessing no other advantage; but the rod, which moves the valve, is not rigidly attached to it. It terminates in a piston in the middle of the tube, on each side of which are spiral springs, held and compressed by rings screwed into the ends of the tube. When the stops on the valve-rod are struck by the arm on the piston-rod, the effect is not immediately transmitted to the valve; but the spring yields, to a certain extent, to the blow before the inertia and friction of the valve are overcome. This gives the piston power to travel some distance after the stop is struck, before its motion is retarded by the admission of steam, and permits the blow to be struck upon the rock before the shifting of the valve admits steam or air to check its force. The extreme simplicity and effectiveness of such an arrangement must be apparent.

Rotation.

There are several modes of effecting the rotation of the drill; but they are nearly all some modification of a ratchet, with a pawl moved by an arm or projection sliding on an inclined surface. Instead of a ratchet a strap may be used, so arranged as to tighten when the arm to which it is attached moves in one direction, and loosen when it moves in the opposite.

The rotation could also be given by means of an arm attached to a fixed point, and connected with the pawl which moves the ratchet by a universal joint. Experience proves that, in order to secure a positive and regular rotation, one ratchet is not sufficient; there must be a second ratchet, or at least a second pawl connected with some non-rotation point, to prevent the drill from turning in the wrong direction, and losing on the forward stroke the rotation given on the back stroke.

The Feed-Movement.

Of the three movements required in drilling rock, the feed appears to have presented the greatest difficulty to inventors, and the drill, now under consideration, appears to be the only one in which these difficulties have been overcome, in a manner entirely unexceptionable by devices at once simple and effectual.

The conditions of feed necessary for a perfect machine are,

That it shall be automatic—not dependant in any manner upon the attention of the operator.

That it shall be self-adjustable and variable, feeding with precision as fast as the tool has power to penetrate the rock, but no faster, varying its feed in the same hole with the varying hardness of the rock or sharpness of the point.

The feed in the Sommelier drill is a very peculiar one. The cylinder is comparatively long, and the piston does not at each stroke traverse the entire length of the cylinder, but gradually approaches the forward end as the drilling tool penetrates the rock.

When the forward end is nearly reached, a trigger arrangement is touched, which, by the recoil of a spring that has been gradually wound up, throws the cylinder forward a certain distance, and brings the piston again to the rear end of the cylinder.

This exceedingly complicated arrangement involves many serious disadvantages. Whatever may be the length of stroke two cylinders of air or steam must be consumed at each movement; and if the shortest stroke is sufficient to give an effective blow, any increase in the length of the cylinder must involve waste of power. This would be no disadvantage, where there was an excess of power, and air was required for ventilation; but it would be preferable to provide it in some other way.

The variable position of the piston in the cylinder renders it difficult to work the valves by the simple device of an arm and tappets, and a separate and independent cylinder is introduced for the purpose of working the valve, involving great complication in the mechanism.

Other drills have been constructed in which the feed was given by means of a fixed nut attached to some part of the machinery, usually the rear end of the piston-rod. The drill-holder passed through this nut, and carried a screw on its outer surface. As the drill was rotated by the mechanism provided for that purpose, it was fed forward through the nut at a uniform rate of progress.

The objection to this device was that no uniform feed could be adapted to a variable rock, and in a uniform rock, if the feed should be too rapid the stroke would shorten, the valve could not be shifted, and the drill would stop. The same difficulty would occur when the cutting-tool became blunt. If, on the contrary, the feed should be too slow, the effect produced would not be in proportion to the power expended.

To overcome these difficulties numerous attempts have been made to secure a variable feed. The mechanism consisted in a spiral thread around the tool-holder, and a nut through which it passed; the nut being turned by a separate ratchet, independent of the regular rotative movement of the drill, would feed the drill-holder a certain distance at each partial rotation.

To render this mechanism self-adjusting, a provision was made that if the drill advanced faster than it could penetrate the rock, the feed ratchet would cease to act, while that which produced the rotation would continue, the two being entirely independent of each other in their movements.

This was very beautiful in theory, but the difficulty was that it would not work in practice, and the cause of the failure is easily explained.

At the forward end of the stroke, a ring, or projection on, or moving with the piston-rod, came in contact with the end of a lever, the opposite end of which carried the pawl which turned the feed ratchet. If the stop did not come in contact with the end of the lever, there could be no feed, and this would be the case whenever the feed was too rapid for the penetration of the drill. But here lay the difficulty; the feed was necessarily given at the instant when the point of the drill was in contact with the rock at the end of the forward stroke, and consequently when it was impossible to screw it forward without great violence to and strain upon the feed apparatus, nothing did stand and nothing could stand such strain. Breakages were incessant, and after much loss of time and money; the machines were abandoned.

In neither of the forms of drill designed by the writer does this defect appear; the feed is given either before the point of the drilling-tool touches the rock, or after it has left it on the back stroke, as will be shown in the description.

Momentum Feed.

In this feed mechanism the tool-holder is firmly grasped by wedge-shaped pieces of steel, called grippers, firmly pressed by a rotate spring, and enclosed in a metallic box called a gripper-box. The feed is given by projections on the gripper-box coming in contact with stops on the cylinder head; this causes the drilling tool to be projected forward until it strikes the rock, when the recoil of the rotate spring forces the gripper pieces, which have been thrown forward, back into their places, and they grasp the drill-rod further back than before the concussion. The force of the blow is relieved by a gum-ring, and the pieces which receive the blow are easily detached and renewed; they are made quite hard and do not wear or batter rapidly. This feed is perfectly self-adjusting, and it is given before the drilling-tool comes in contact with the rock; consequently the strain referred to as a fatal objection to other contrivances for feed is avoided.

Screw Feed.

Although the momentum feed performs well, and none of the parts connected therewith have broken in any of the experiments that have been made for a long time, it is less simple and effective than the self-adjusting screw feed.

The attempt to feed at the end of the forward stroke by the rotation of a nut proved a failure; but by rotating the nut on the back stroke the difficulty is obviated.

Nothing could be more simple than the mechanism by which this very important result is secured. It consists simply in allowing the forward movement of the piston, instead of rotating the nut directly, to compress a spring which on the back stroke produces the rotation by its recoil, and thus gives the desired movement at a time when there is no strain whatever upon the parts.

The parts are so proportioned and adjusted that if the drilling tool feeds forward too rapidly the movement of a rod and the throw of a ratchet are lessened, and a perfect compensation is secured, thus fulfilling every condition of a perfect self-acting and self-adjusting movement.

The drilling-engine which has been described appears to

fulfil every condition that could possibly be required. Its total length is only about 30 in., width 6 in., and height 8 in., so that it can operate in the smallest space possible for any effective machinery, and can be placed in any desired position. Its weight is only 125 lb., consequently one man can carry it or move it about at pleasure. The number and force of the blows per minute which it is capable of delivering are dependant simply upon the pressure and area of piston, and are limited only by the power of steel to resist the force of the blows. This is equally true of every other form of drill in which the blow is given by the direct pressure of air or steam upon a piston, and nearly all are constructed on this principle; rapidity of penetration, therefore, being simply a question of power and steel, is no criterion by which to judge of the merits of a machine, but there is a vast difference in the economy of power, the economy of space, the liability to derangement, and the cost of repairs, as also in the facility for adjustment and operation.

In other drilling-engines the cylinder which contains the piston advances on a frame or support as the drill penetrates the rock.

In the drill now under consideration, the cylinder is stationary, and the drill-rod alone advances, thus dispensing with the sliding-frame altogether, and greatly simplifying the mounting.

In all other drilling-engines the tool is inserted in a socket from the forward end; as a consequence the machines must stand at a distance of several feet from the face of the work, they must be advanced or removed by means of a carriage, generally on rails. If several drills are working at the same time, in case one point should break, all must be withdrawn before a fresh drill can be inserted, or the machine must be dismounted.

All this difficulty and delay is avoided by passing the drill-rod through a hollow piston from the rear end. Whatever be the number of drills at work, any one tool can be readily withdrawn and another inserted without interfering with any other. No carriage is required for mounting the drills, they stand close to the face of the rock, and can be immediately replaced after a blast, to remove drilling without waiting for the removal of the debris which the blast had detached. This is an important consideration to secure a rapid advance, and it is claimed to be an advantage that no other plan possesses.

Mode of Mounting the Drills.

The satisfactory prosecution of mining or tunnelling operations requires not only that a drill or perforator should be provided that is applicable to the purpose, but it must be so mounted as to permit its convenient use.

The conditions to be fulfilled in mounting the drills are,

1. That the plan adopted shall admit of the erection and removal of the drills in the shortest possible time.
2. That it shall permit the resumption of drilling operations as quickly as possible after a blast, so as to secure the greatest number of blasts in a given period of time, the progress being in proportion to this number.
3. That the drilling of the holes should interfere as little as possible with other operations, especially with the removal of the debris.
4. That the most perfect mobility should be secured, admitting of drilling in any position, at any angle, or at any elevation.
5. That the adjustment of the drills, and the fastening of them in any desired position, should require the least possible period of time.
6. That the manipulation should be effected with the smallest number of attendants.
7. That if any drill should break, another can be inserted without delay, and without stopping any other machine.

The Mont Cenis drills are mounted on an iron frame of considerable size and weight, which is supported upon wheels, and runs forward upon a railroad track. The perforators can be moved horizontally or vertically on arms which admit of these motions, but their extreme length does not permit holes to be drilled at an inclination varying much from the direction of the gallery.

The machine is so large, and the spaces on each side consequently so small, as not to permit the convenient removal of the debris when the perforators are at work, consequently there is considerable delay in resuming operations after a blast, independently of that which is caused by the defective system of ventilation. In consequence of these difficulties, it has been found practicable to blast only two or three times in twenty-four hours.

In the experiments made by or under the direction of the writer, several modes of mounting drills were tested, but only that which gave the most satisfactory results will be described.

The final result of many improvements is exhibited in a stand with two hollow columns, the base of which rests on a cast-iron tripod, in which are three steel points, which, by means of a ball-and-socket joint, accommodate themselves to the inequalities of the surface, and require no adjustment whatever. When steam is to be used, the base should be hollow, and divided by a transverse partition into two apartments, into one of which the live steam is admitted, and into the other the exhaust.

The size of the columns should be about 4 in. exterior diameter, the thickness $\frac{3}{4}$ in., and the material wrought iron.

The connexion at the top is by means of a strap 2 in. deep, $\frac{3}{4}$ in. wide, with rings to embrace the columns tightly. To obviate the loss of time and the instability which result from too great length of the top screws, a second tube is provided to slide inside the column, like the tube of a telescope. This tube may be extended a foot or 18 in. at one movement, and held by a pin, which passes through holes in the column, and upon which the bottom of the inner tube rests.

The inner tube at its top end carries a nut to which it is rivetted, and through this nut passes the steel-pointed set screw, secured, when in place, by a jam nut, or by passing a rod through the holes in the screws of the two columns, which furnishes a convenient mode of locking them.

Each stand may contain three or four drills, but three is a convenient number for driving a tunnel gallery 6 ft. high. The distance between the columns of each stand is 10 in., or 18 in. from out to out. The number of stands in use will depend upon the width of the gallery. In a heading 6 ft. high and 15 ft.

wide, it might be expedient to use four stands mounting twelve drills, in order to secure the most rapid progress possible; but two stands with six drills would give very satisfactory results, as two or more sets of holes could be drilled before blasting.

It will be observed that there is not a single screw connected with any of these movements; that keys have been substituted in every instance; that the keys are placed in a direction at right angles to the direction of the jar or strain, so that there is but little tendency to rattle loose; that every clamp-piece has a transverse notch, through which the key passes; and that every key is wired.

The advantage of effecting the adjustment by means of keys instead of screws, became evident after a short course of experiments at the Franklin Tunnel, in Pennsylvania. The screws required to be turned in effecting the adjustment were not all of the same size; wrenches had to be adjusted to fit. Sometimes they would be mislaid, and time lost in looking for them. The annoyance from this cause was considerable: those who experienced it can appreciate the advantage of a system in which all the fastenings can be loosened in a few seconds by three or four light taps with a hammer, or a stone if the hammer is mislaid, and tightened again as readily.

As the distance between the columns is 10 in., while the width of the drill cylinder is 6 in., and its length 10 in., there is a play of 4 in. to the right or left; and as the point of rotation at the forward end is about 4 in. in advance of the line of the columns, the rear end of the cylinder when placed on one side will swing clear of the column on the other side. This will admit of a range of horizontal movement exceeding 90°, a degree of mobility which would be impossible with any other than a very short machine, and in securing its stability is not sacrificed.

In a vertical direction there is no limit to the movement; the drills may be placed at any angle, from vertical upwards to vertical downwards.

As the drill cylinder can be placed in contact with either column, it is possible to work as closely to either side of the tunnel as may be necessary. A narrower stand could possess no advantage in this particular.

To shift the position of a drill it is not generally necessary to move the forward pivot it is only required to loosen the two column clamp keys; and the two rod clamp keys to secure a movement both horizontal and vertical. A minute should suffice for this adjustment.

The india-rubber pipes which carry the live and exhaust steam or air to and from each drill are not disconnected, except when a drill is to be sent to the shop for repairs; they remain attached to the drills and stand, and do not interfere with the movements.

If a drill point should break or become so dull as to require sharpening, the box at the rear end which holds the feed-nut is thrown open, the drill rod with the nut attached is drawn out, and another rod and nut inserted; there is no necessity for losing time to back the drill-rod out by unscrewing the feed-nut as in other drills.

If it should become necessary to remove one of the machines from the stand and substitute another, this too is very rapidly effected. The key in the plug at the forward end of the cylinder must be knocked out, the wires removed from the pins at the rear end, and the hose disconnected. As the hose couplings are made upon an improved plan without screws, the whole operation is performed with great celerity. All the couplings of pipes and hose are connected by simply pressing them together with the hand, and disconnected by pressing a spring and pulling them apart.

In ordinary tunnelling, the most difficult portion of the labour and that which consumes the most time, consists in drilling the holes for the blasts. At the Hoosac Tunnel, where accurate records of all the operations have been kept by statisticians employed for the purpose, it appears that the average progress in drilling by hand in the talcose slate rock, a rock of average hardness, is 46 in. per day of eight hours, or about ten minutes to an inch. In the same rock the machines should readily drill at least 2 in. per minute.

The substitution of machine for hand labour in drilling is therefore very important, if other essential conditions can be also complied with; these are:

1. A mode of erecting, applying power, and removing the drills expeditiously.
 2. Facilities for resuming drilling operations immediately after a blast without waiting until the material blown down has been removed on cars, and without interfering with its removal.
 3. Ample power for operating the drills.
 4. Perfect ventilation at all times.
- Other conditions of accelerated progress which may be considered secondary are,
5. A convenient mode of furnishing light.
 6. A convenient mode of maintaining the alignment and grade.
 7. The best mode of loading and blasting holes.
 8. The most safe and powerful explosive agent.
 9. The best mode of protection against stone projected by the blasts.

These subjects will be considered in the order in which they have been stated.

Machinery to aid in erecting and removing the Drills.

The drill which has been described in this paper weighs about 125 lb., and the stand 180 lb. Three drills, mounted with stand would weigh about 600 lb. This is a very manageable weight; six men, three on each side, would find no difficulty in carrying a stand with its attached drills, without any machinery whatever, and a single drill could be readily lifted to change position, or carried away for repairs by one man.

These are great advantages over heavier forms of drilling engines; nevertheless, to avoid manual labour as much as possible, several plans for handling the stands were devised. The one to which a preference has been given consists of a low car with wheels twelve or fourteen inches in diameter. On the floor of the car is laid a circular track on which the two wheels of a trussed lever revolve. A centre pin keeps the wheels on the circle. The trussed lever is about 20 ft. long from the centre to the forward end, and 15 ft. at the rear end; at the top are two ties of angle iron, which also serve as rails for the

wheels of the small roller which carries the counterbalance weight. Four braces support the ends, and form the truss.

At the forward end is a swivel, from which are suspended two short pieces of chain, with hooks to clamp the columns, and grasp them at any point. The counterbalance weight is run out, by means of the crank, to a sufficient distance on the short arm, to balance, or nearly balance, the weight of the drill-stand. The angle-iron is pierced with holes, and a pin holds the weight in any position; when the stand is laid on the car, the counterbalance weight is then rolled to the centre, when the lever can be removed from the stand, and another picked up and transferred to the car in a similar manner.

To understand the advantages resulting from the use of this apparatus, it must be observed that, when a blast is made, the great mass of rock falls immediately in front of the face, and very little of it is projected more than two or three yards. A movable section of track can therefore be laid to within 15 or 18 ft. of the face, by turning over a few stones, if any are in the way. The long arm of the trussed beam will then reach entirely over the pile of stones, and place the drill-stands just where they are required. The base of the stand occupying a space of only 8 in., and its distance from the face of the rock being less than 2 ft., the stones within this distance can be thrown back in a very minutes, without waiting to load them upon cars. If any piece of rock is too large to be readily removed, it can be picked up by the trussed beam in the same manner as the drill-stands. As soon as a space of 2 ft. from the face of the rock has been cleared, the stands can be placed, the pipes connected, and the drilling resumed; and while this operation is progressing, cars can be brought forward, and the material removed before the next set of holes shall be prepared for blasting.

In this operation will be perceived a striking advantage in the present form of drill over perforators, in which the drilling tool is inserted in a socket at the forward end of the piston-rod. Allowing only 1 ft. for the projection of the piston-rod when at the forward end of the stroke, and the length of the drilling tool not less than 8 ft., the front of the drill-cylinder must be at least 4 ft. from the face of the rock, and, in some, 7 or 8 ft. This great projection of the drilling tool also requires that its forward end shall be supported when the hole is commenced. With such machines it is almost impossible to resume the drilling of a new set of holes until the material from the former blast has all been carried out, and thus these two operations, which, to secure rapid progress, should be carried on simultaneously, must be performed successively.

By dividing the frame as in the plan of working adopted by the State Commissioners at the Hoosac Tunnel, some advantage is gained, as one-half of the space can be cleared, the track laid, and the half carriage run forward to recommence drilling with a portion of the machines, before the balance of the space is cleared; but it is believed that no other plan that has ever been proposed will permit the resumption of drilling operations after a blast, with as little loss of time and as little manual labour as the use of the tubular stands and the trussed lever for handling them.

When the trussed lever is not in use, it is run off upon a side track, which also serves as a place of deposit for cars, to keep the main track clear.

The second condition which has been enumerated as essential to secure the most rapid progress in tunnelling is the possession of facilities for resuming drilling operations immediately after a blast.

In the consideration of this subject, it will be assumed that the heading or advanced gallery is of the same sectional area as that given to the Hoosac Tunnel, which is 15 ft. wide and 6 ft. high, and that the problem to be solved is to determine the mode by which the most expeditious progress possible can be secured in a gallery of these dimensions.

One condition of rapid progress is satisfied in the use of the trussed lever for expeditiously erecting and removing the drills, and placing them in position before the loose material is carried out; but to make these facilities available, there must be,

1. A properly constructed car, on which to transport the drills.
2. A means of quickly removing the powder smoke.
3. A convenient means of attaching the pipes which convey the power, and preventing leakage of steam.
4. A means of supplying fresh air.
5. A supply of water for the holes.
6. Such a disposition of pipes, tracks, and machinery, as not to interfere with operations, or be exposed to damage.

The car upon which the drill-stands are removed consists of a frame 12 ft. long, supported on low wheels; on the top are several cross pieces 4 ft. long. As the drill-stands are 6 ft. long and one foot and a half wide, the top of this car would afford ample room for four stands. The trussed lever takes hold of the back of the stand, and as it is turned on the swivel the face which was next to the rock is presented to the car, the front of the drill cylinder projects downwards, and the rear upwards. Thus they lie in perfect security, the columns only being in contact with the car.

The power used is supposed to be steam, and the manipulations described have reference to its use; but if compressed air should be employed, they would be very similar.

In the use of steam it is desirable that the joints should be tight, and the glands all accessible, so that they can be tightened if found to leak, also that the exhaust steam, instead of being allowed to escape into the tunnel, should be carried away by a separate pipe.

The car upon which the drill-stands are transported is connected by rigid couplings with the portable boiler, and carries in a secure position beneath the axles the steam-pipe which supplies power to the drills.

The end of the steam-pipe projects about a foot beyond the front end of the car, where there is a globe valve, and the connection will be observed that the only connections to be made in continuation of the pipe is by about 10 ft. of india-rubber steam hose, and terminated with 10 ft. of metallic pipe having upon it as many nozzles as it is proposed to use stands.

To each nozzle is attached 2 or 3 ft. of inch and a quarter india-rubber steam hose which connects the steam-pipe with the base of each stand.

applying steam will be a single one at the base of each stand. The gum pipes belonging to each stand are not disconnected, except when a cylinder is to be removed from a stand and another inserted. The short pieces of hose connected with the 10 ft. of metallic steam-pipe, which lies in front of the stands, remain permanently attached thereto; and when the stands have been placed upon the car ready for removal, the piece of metallic pipe with its attachments is laid on top, the flexibility of the gum hose permitting this to be done without inconvenience.

The pipe to carry away the exhaust should be larger than the steam-pipe, say 6 or 6 in. in diameter. This pipe is also 10 ft. long, lies in front of the stands beside the steam-pipe, and is furnished with the same number of nozzles and short pieces of hose. The exhaust-pipe and hose may be light and thin, as the pressure is very slight.

The continuation of the exhaust-pipe into the vacuum-box, to be hereafter described, should be by short pieces of gum-pipe in lengths of 10 ft. or 12 ft., so as to admit of convenient extension as the work progresses without extending the vacuum-box more frequently than in lengths of about 16 ft.

This piece of exhaust-pipe, with its attachments, is also to be removed with the stands preparatory to a blast, and placed on the car.

The track upon which the car runs is a temporary one, composed of sections of two rails, each 12 ft. long, connected by cross-rods. The rails are dovetailed into each other at the ends; they are laid upon the bottom without cross-ties, and levelled roughly with a few blocks or stones where support may be required.

As the car is run back, these sections, which are very light and readily handled, are lifted and placed upon the car to the extent of about six sections, beyond which there is not much danger of breakage.

It has been stated that the car is attached permanently to the boiler or steam-generator, and to this must be also attached a tender with fuel and water. Twelve drills would require a 40 horse power boiler, weighing about 8500 lb., water in boiler 1500 lb.; water to run drills an hour, 2200 lb.; drills and stands, 2000 lb.; fuel for an hour, 500 lb.; car, tender, &c., 8000 lb. Total weight to be moved, say, 7 tons.

By the aid of a pinion and crank applied to the driving-wheel, the train can be removed by one man to a distance of 150 ft. in a period of time not exceeding five minutes.

In returning to resume work, it is obvious that the train can be moved with the crank quite as fast as the rails can be laid and adjusted.

It is proper to observe that space in a tunnel is very limited in two directions, in height and width, but in length there is practically no limit. By the proposed plan of operations, the space immediately behind the drills, where the pile of debris lies, is entirely unoccupied by any machinery or pipes, excepting a small portion of one corner where the vacuum-box is placed. The boiler and tender, car and contents, take up only 4 ft., leaving 11 ft. unoccupied, which would be amply sufficient for two tracks; but it must be observed that the track occupied by the boiler extends back, say, about 300 ft., beyond which the whole tunnel is unoccupied by any machinery connected with the arrangements for mechanical drilling.

It cannot be doubted, therefore, that the proposed machinery and plan of operation afford facilities for quickly erecting and removing the perforators without interfering with the removal of material.

The means proposed for removing the powder-smoke are the same as those for ventilating the tunnel and furnishing draft for the boiler, which will be more fully considered under the head of Ventilation; it is sufficient to state here that an air-box is carried in the angle of the tunnel to the very face of the rock, that it is protected by piling stones or logs upon it, that a vacuum is produced in the pipe by suitable means on the outside of the tunnel, that the powder-smoke and vitiated air are drawn into this pipe, and carried out without being allowed to poison the air of the whole tunnel, as is the case where air is forced in by compressors, and the smoke driven out at the end.

The means of applying the power are very simple. In the first attempts of the inventor to use steam in tunneling, the boiler was stationed about one hundred and fifty feet from the perforators, and the steam carried for this distance in pipes. To accommodate the length of the pipe to the advancement of the work, the last joint was made with a smaller pipe sliding within a larger one, and a section of gum hose, or rather several pieces of smaller diameter, connected the steam-pipe with the drill-stands. This arrangement was much more inconvenient than that which has been described, in which no extensions of steam-pipes are necessary, but only a gradual advance of the steam-generator on the track as the work progresses. This permits firm and permanent joints except at the stands; and if one of these connecting-joints should become detached, and permit the escape of steam, the men are in no danger, for they are behind, and by the system of ventilation adopted, the air moves towards the face of the work, and the escaping steam would be drawn into the vacuum box before it could escape into the tunnel to any considerable distance; besides the supply-valve at the boiler would be immediately closed by the attendant, and the steam shut off.

The supply of water for the holes while drilling does not require that a constant jet should be injected into each hole while being drilled. A supply at short intervals is sufficient. The report of the commissioners on the Hoosac Tunnel states, that the provision for injecting water into the drill holes was only partially availed of. Practically, the most simple and convenient mode of furnishing water for the drill holes would be to carry a small tank upon the forward end of the car, where it would be very accessible, and inject the water by means of large syringes, one of which to each stand would be amply sufficient. Or, if preferred, a close tank could be suspended below the axles or along the middle of the car, connected with an air-chamber into which air could be pumped by a hand-pump attached to the car, so as to produce a pressure upon the surface, or still more simply a portion of steam could be admitted to the tank above the water, so as to produce a moderate pressure; the water could then be thrown into the holes by means of a hose. The water question is a very simple one, and presents no difficulty; it is, moreover, independent of the system of mechanical tunneling that may be adopted, and is as necessary for one as for

another. The car, however, offers facilities for carrying the water, which other systems might not as conveniently furnish.

Power for Operating Drills.—Engineers who have heretofore attempted to solve the problem of determining a practical mode of applying machinery to facilitate the operations of tunneling, have uniformly assumed that the creation of the power inside of the tunnel was impossible, and that it must necessarily be transmitted from some source of power on the outside, if machinery for drilling rock be used in any manner. In this consists a radical difference between the system proposed by the writer and all others; he does not assume the impossibility of generating power in a mine or tunnel, but does generate and apply it just when and where it is required for use, and that, too, as effectively, conveniently, and simply as if the operations were conducted on the outside.

Before committing the Governments of France and Sardinia to the great expenses required in the introduction of the system of working machinery by compressed air, elaborate experiments were made by a properly constituted commission to determine its practicability.

Assuming that a machine could be invented, capable of drilling holes in rock by the agency of compressed air, it became necessary to determine,

1. The number of perforators that it would be desirable to operate at one time.

2. The quantity of air at the required tension necessary to operate them.

3. The additional quantity of air necessary for ventilation.

4. The amount and kind of power necessary to furnish the air at the proper tension, and the best mode of providing it.

5. The capacity of the reservoirs necessary to contain the compressed air, and maintain uniformity of tension while working.

6. The allowance to be made for loss of power by transmission through the pipes.

The number of perforators used at the Mont Cenis Tunnel is nine, and the average number of blows per minute is 270, with an average consumption of air at each stroke of about 185 cubic inches.

Nine perforators making 270 blows per minute would consume 190 cubic feet of air per minute at a tension of five atmospheres, equivalent to 950 cubic feet per minute, at the ordinary tension.

The amount of air required for ventilation was estimated by assuming, as the result of experiment and observation,

Ten cubic metres of air per hour as requisite to furnish ventilation for each man.

Seven cubic metres of air per hour to support combustion for each lamp.

250 cubic metres of air per hour to dilute the gases generated by the explosion of one kilogramme of powder to an extent sufficient to permit them to be breathed.

The consumption of powder was estimated at 24 kilogrammes in 24 hours.

It was found that the quantity of air required for ordinary working at the atmospheric tension was 2118 cubic feet per minute, to be increased after a blast.

The power required at both ends of the tunnel to work the hydraulic compressors was estimated to be 650 horse power.

The apparatus required to compress air at the Mont Cenis tunnel consisted of cylinders into which the water was admitted at the bottom, under a sufficient head, forcing the air into a smaller space at the top; when the proper tension was attained, the air opened a valve and escaped into the reservoir.

As the horse-power expended is measured by the space passed over under a given pressure, it is evident that if air is compressed by this system into one-fourth of its original bulk, the power expended in compressing it will pass over a space represented by four, while the air occupies a space represented by one. Therefore the power secured by the use of the compressed air cannot be more than one-fourth of the power expended in compressing it; to be reduced still further when friction and other resistances are considered.

Under other systems of compressing air the loss may be reduced, but when power must be provided exclusively for the purpose of compressing air the loss must always be considerable. When air can be compressed by the use of power already existing, and not otherwise utilized, it is the best and most economical agent possible. If the uniformity of motion and resistance is maintained by heavy fly-wheels, the loss in compressing air by the agency of steam will be reduced.

Whatever may be the plan adopted for compressing air independently of the loss of power attendant upon this operation, there must be another serious loss in its transmission if the velocity be great.

To obtain data by means of which to determine this loss a series of extremely valuable experiments were made at the Mont Cenis Tunnel, by a commission of gentlemen of eminent scientific attainments, appointed by Government, consisting of Messrs. De Nérache, Giulio, Ménabréa, Rura, and Sella.

After having satisfied themselves that the hydraulic air-compressors could furnish a large quantity of air at high pressure, the commission undertook to determine carefully the diminution of tension, which, near the drilling-machines, would result from the resistance of the sides of the pipes to the motion of the air. With this view, special experiments were instituted on a system composed of 801 metres of metallic pipe, continued by 98 metres of india-rubber hose. Mercurial gauges were used to ascertain the tension of the air simultaneously at different points, and observations were also made on the time of passage and the velocity of the air which escaped. These data, compared with the diameter of the pipe, enabled the observers to determine the force of the elastic fluid at the commencement and at the end of the pipe, and enabled them to trace accurately a curve for the interpretation of the results. In extending and comparing these calculations, the experimenters formed the following Table, which gives the results of their observations:

Two laws will be observed by an inspection of this Table.

1. The loss of tension or resistance is inversely as the diameters of the pipes.

2. The loss of tension is directly as the squares of the velocities.

The quantity of air required per minute at the Mont Cenis Tunnel was 2118 cubic feet per hour, equivalent to 85.3 cubic feet per second at the ordinary tension.

If this air is passed through a pipe 8 in. in diameter, the velocity must be 101.6 ft. per second in the pipe, or 31 metres per second at the ordinary tension, or, condensed under a pressure of four atmospheres, the velocity must be 8 metres per second.

Loss of Tension for one thousand metres of pipe, expressed in millimeters of a column of mercury.

Velocity of air at the entrance of the pipe in metres per second.	Diameter of Pipes in the clear expressed in decimals of a metre.					
	0.10.	0.15.	0.20.	0.25.	0.30.	0.35.
1	6	4	3	8	2	2
2	26	18	13	11	9	8
3	62	42	31	25	21	18
4	108	72	54	44	36	31
5	167	112	84	67	56	48
6	233	156	117	94	78	67

It will be perceived from an inspection of the Table that the loss of tension is nearly in proportion as the square of the velocity; and as the supposed diameter, 8 in., is nearly one-fifth of a metre, the fourth column should be used.

The loss of tension in 1000 metres, with a velocity per second of 8 metres, would be 216 millimetres of a column of mercury, equal to 8½ in., or more than one-fourth of an atmosphere.

If carried 4 miles, or 6437 metres, the loss would be one and eight-tenths atmospheres, or 27 lb. per square inch, reducing an effective pressure of 60 lb. at the reservoirs to 33 lb. at the drills.

If by the system of hydraulic compressors only one-fourth of the power expended in compressing air can be utilised in the air thus compressed at the reservoirs, and if an additional loss of nearly 50 per cent. is sustained in the transmission of the air to the middle of the Mont Cenis Tunnel, only one-eighth of the original power would remain as available for operating the perforators at that distance from the reservoirs, and in this calculation friction and other ordinary resistances have not been considered.

A serious objection to the use of compressed air as a motive power in tunnelling arises, therefore, from the great loss of power in compression and transmission, from which steam, if applied directly and without transmission through long pipes, would be entirely exempt.

If only a small number of drilling-engines are in operation, so as to reduce the velocity of transmission, then will the loss of power also be reduced; and if the air is not in use, and no escape permitted, the pressure at the reservoir would be transmitted to a great distance without diminution.

In consequence of the loss of tension which results from the transmissions of air to long distances through pipes, it follows that when a gallery in subterranean operations is extended to a distance of several miles, expedients must be used to compensate for this loss.

If the perforators require a pressure of 60 lb. to the square inch, they cannot be advantageously operated with 30 lb. or 35 lb., and therefore it will become necessary either—

To reduce the number of perforators in use, involving a reduction in the rate of progress, or increase the initial tension by an increase in the power at the reservoirs, or increase the number or diameters of the pipes which carry the air into the tunnel.

Water may be used as a motive power, and could no doubt be applied advantageously in mining coal, and similar operations, by means of a water engine, the power being carried in pipes, and the connexions made with india-rubber hose; but the movements of such engines must be slow; the number of blows in a given time much less than can be attained with some form of pneumatic power, and the resistance in the transmission of the power much greater. The problem of the application of water to tunnelling will not therefore be discussed at this time.

It remains to consider the application of steam as a motive power in tunnelling.

Why steam should have been so generally rejected by engineers as inapplicable, it is difficult to understand; probably because opinions were formed hastily, without investigation. The apparent difficulties are far from insuperable.

What are the supposed difficulties in the way of the direct application of steam as a motive power in tunnelling, and what are the conditions of success?

1. If steam is generated outside a tunnel, it cannot be carried for any considerable distance without great losses by condensation.

Very true, and the remedy is, not to generate the steam outside, and not to carry it in pipes more than 20 or 30 feet.

2. If generated inside, we encounter, The inconvenience of a boiler in the tunnel, with the occupation of space required for other purposes.

The necessity of carrying fuel and water into the tunnel.

The difficulty, usually considered an impossibility, of creating a draft for the boiler.

The escape of smoke and gases generated by combustion.

The escape of steam into the tunnel.

The heat of the boiler, pipes, and escaped steam rendering it impracticable for the men to work.

The damage to such bulky machinery from blast.

The difficulty of removing such machinery to a safe distance.

The danger of explosions.

Can any other objections be thought of? If not, an attempt will be made to show either that there is not the slightest force in any that have been stated, or that the remedy is simple and inexpensive.

The key to the solution of this important problem of the direct application of steam to tunnelling consists simply in the combination of a steam-generator with a vacuum pipe, a combination which fulfils every condition required in the economical and convenient generation and application of steam, and at the same time secures a ventilation incomparably more perfect than any other system can furnish, even at an expenditure in construction and maintenance of machinery many times greater.

(To be Continued.)

THE INSTITUTION.

THERE can be but few English engineers who would not acknowledge to some degree of pride in the Institution of Civil Engineers, even although not themselves members of this, the single representative body of our profession. It is honoured, too, and respected abroad, and that in every part of the civilised world. Besides its present and practical advantage as a focus and repository of engineering knowledge, and as affording some guarantee of the qualifications of its members, the Institution has a history of which the whole profession is proud, and which invests the unpretending house in Great George-street with many cherished associations. None who have sat in its theatre when Stephenson and Brunel presided over and took part in the discussions, could hear, except with deep pain, of any present dissensions there calculated to lessen its usefulness and influence. Although a purely voluntary association, as much so as any club, and possessing no powers of interference with engineering practice or practitioners, the Institution nevertheless does exercise a moral influence upon, and impart a tone to, English engineering, to which the profession and the public alike owe much. Although engineers have been said to be rough and rugged in their natures, as are the materials with which they deal, the Institution, as much as, if not more than, any other influence acting upon its members, brings out the priceless qualities of the gentleman, and shows that only reason, forbearance with opposition, and courteous demeanour can carry conviction, and propitiate good feeling.

In material prosperity, the Institution was never in a more flourishing condition than now. It has a considerable accumulated property, some 25,000*l.*, besides, of course, the benevolent fund of about the same amount, and it has an annual income much in excess of its total expenditure. So highly, too, are the advantages of membership now valued, that there can be no doubt that the number of members and associates would increase nearly as rapidly as heretofore, even were the annual payments considerably greater than they now are.

The Institution has long needed a more commodious home. The present house in Westminster is not only wanting in many of the essentials of due accommodation, but it is altogether unbecoming the wealth and influence of the profession. The library is not one-third as extensive as it should be, especially now, when professional books, professional periodical literature, and parliamentary proceedings upon private bills have become so numerous and voluminous. Accommodation is required also for models and plans, and, we may just add, for statues, busts, and portraits of engineers, and for paintings of merit of the more important works of our profession. Once provide for these, and with the present nucleus they would steadily accumulate, and in time become a collection of priceless value. We need not point out to any one knowing the present building, that the waiting-room is altogether unfitted by its darkness for even a third-rate solicitor's office, or a waiting-room of the meanest character. Even the meeting-room of the council, used as it also is for the secretary's office, is by no means what it might be. As for the lecture-theatre, it is very often overcrowded on the occasion of any discussion of special interest, and scores of visitors are often unable to get inside the door, to say nothing of finding no seats. On the occasion, too, of the president's annual *conversazione*, the crush and discomfort are simply outrageous. Growing as the Institution now is, it requires an altogether better and larger building, and in no case should the members permit the patching-up of neighbouring houses for their use, as was proposed last year. The movement then made to obtain funds for the erection of such a building, upon freehold property, resulted in the promise of 25,000*l.*; and, but for the strong opposition of some of the members, the undertaking would have, doubtless, been now well in hand. Considering, however, the general collapse of engineering undertakings since that time, the temporary abandonment of the scheme is not so much to be regretted. The necessity will be felt, in greater force, in a few years; but when, possibly, members may be neither so ready and liberal as they were last year, and when another freehold site so desirable as that then available cannot be had for twice the money. No one in the profession, and knowing the *habitat* of the London engineer, will dispute that the most desirable of all sites for a permanent home for the Institution is that occupied by the houses 15 and 16, Great George-street, a site commanding a full view of the Houses of Parliament, Westminster Abbey, Westminster Hall, Westminster Bridge, close to all the public offices, and most accessible to all having business at the Institution.

It is to be hoped, too, and that most earnestly, that

another inquiry, like that conducted in private by the council, last winter, may never again, no matter *what* the occasion, be attempted. No doubt the case was a most unpleasant one, and, on its face, greatly against the person implicated; but it is, we may say, certain that he committed no legal offence, and that his past life, his own explanations, and very much of his conduct in the affair itself were wholly opposed to the presumption of any moral delinquency. No doubt, however, that acting as a merchant merely, and not at all in a position of trust, as was so persistently represented, he committed a serious error of judgment, and brought upon himself a commercial misfortune, under circumstances, certainly, inviting unfavourable comment. We do not wish, however, to re-open the case—our readers know how fully we dealt with it at the time; but we would point to it merely to repeat how essentially unsuitable is such a tribunal for hearing such cases, and awarding punishments so fatal in their nature. Indeed, in all so-called "courts of honour" there is an element of danger which does not exist in courts of law. While an ordinary criminal jury feel themselves in no way prejudiced in acquitting a prisoner in the absence of sufficient evidence, even under very suspicious circumstances, a jury of peers feel that anything approaching a grave suspicion resting upon one of their own number must react in a damaging manner upon themselves. So in the case in question. There was much in it that had never been explained at all; there was good law to defend all that was explained; and yet the case undeniably had a bad look. Who will not believe that many members, really not understanding more than the general bearing of the matter, and anxious only to preserve the honour of their body, as much for their own sakes, too, as for that of the Institution, were ready to cry "Vote! vote!" even before the accused had been allowed to speak in his own defence? May no such occasion ever arise again, no matter what the pretext, so long as the case is within the scope of the civil or criminal law, except as the result of proceedings at law. Cases not within the scope of the law, but demanding inquiry, may sometimes arise, and in these alone let the right of inquiry be exercised. And let the members have the courage to enact a by-law, that whoever brings forward what is in its nature a case for the law, upon merely private testimony, shall himself be thereby rendered liable to expulsion.

Another point. It is to be regretted, for the sake of the good feeling and harmony which should always prevail in the profession, that the late opposition to the application of a junior body of engineers for a charter, empowering them merely to hold a moderate and necessary amount of property in their corporate capacity, should have been opposed by the Institution. This opposition can be defended upon no ground of justice or policy, but only by the admission of professional jealousy, and the Council of the Institution have already had the opportunity of reading in our columns the spontaneous and energetic condemnation which their course has drawn from one of the ablest, most high-minded, and popular engineers in France, M. Eugène Flachat himself, the president, and for the seventh time since 1842, of *La Société des Ingénieurs Civils*, the representative body of the profession in that country. Indeed, no dispassionate man could take any other view, and even the President of the Institution, in his recent letter to us, admitted that he warmly desired to see kindred bodies increase in number and importance, while yet most strangely and illogically thinking that to empower these bodies, as they should all be empowered, to hold sufficient property for their own necessary purposes was to "establish" a "rival," although the so-called "rival" has been fully "established" since 1856. Now that the occasion has passed, many members of the Institution will regret this mistaken policy. Several have privately asked us already whether the Institution and the younger society cannot "work together." Certainly not, and there is no weighty reason whatever why they should. The members of the latter have a genuine respect for, and even a pride in, the former, many of them, indeed, being also members of the Institution. But they desire to act so far independently, just as at least a dozen other engineering bodies are now doing, with real advantage to themselves and to the profession. Let them continue to do so, placing no obstacle in their way, and much unpleasant feeling will be avoided, while the older society, as heretofore, will have nothing to fear.

THE CLEVELAND IRON TRADE.—There is not much change to report in connexion with this trade. The manufactured iron trade is looking somewhat better, and during the last few days a Middlesboro' firm has booked a considerable Continental order for rails.

THE GARTSHERRIE IRONWORKS.

THE notion of there being an aristocracy of pig iron may seem a strange and far-fetched idea, yet it will undoubtedly impress itself upon the mind of any observing visitor to those great and celebrated ironworks which form the subject of our present notice. The Gartsherrie works form the first and original establishment of Messrs. William Baird and Co.—a firm which now owns upwards of forty blast furnaces in various parts of Scotland, together with all the necessary appendages of mines, collieries, and land for working such an enormous concern. It is not, however, the size and extent of this commercial establishment which gives rise to the idea of an aristocracy of iron, but it is the reputation and celebrity of the brand "Gartsherrie" to which this expression refers. A ton of pig iron marked "Gartsherrie" will command a price in the market which not only is above the average of the general quotations, but which is also entirely unaffected by the smaller fluctuations in the prices of pigs, the general variations between supply and demand having no influence upon that select brand. The same pig iron, taken to any distant port, will find itself in a similar position by virtue of its brand, and the act of effacing this brand, although it could not possibly alter the intrinsic value of the material, would reduce its market price by something like 10 or 12 per cent. It is such a fact, granted and acknowledged by all the world, which conveys the idea, and justifies the expression, "aristocracy of pig iron."

The Gartsherrie Ironworks are situated between two main lines of railways, the Caledonian and the North British Railway, and are connected by sidings with each of the two lines. The works consist of sixteen blast furnaces placed in two parallel rows, eight on each side of the navigation canal, which passes through the works, and forms one of the main arteries for their traffic and locomotion of materials. The two rows of furnaces are placed face to face, with their pig-beds bordering the canal, and the lines of rails for the supply of raw materials placed at a higher level behind each row of furnaces. The two lines of rails are connected with each other by a railway bridge which crosses the canal and the lower level of the works, and the traffic is carried over this bridge and on the lines in the works by means of several small locomotive engines and the usual coal and ore wagons. The eight furnaces on one side of the canal have been erected at different periods, and they accordingly vary in height—between 38 ft. and 60 ft.—and also in other dimensions. The opposite row of furnaces is a set built from one pattern, and all alike in every respect. They are 40 ft. high, open-topped, and worked with raw coal and hot blast. The blowing-engine supplying these eight furnaces is a single-cylinder beam-engine, constructed in its valve arrangement similar to that of Cornish pumping-engines. The steam-cylinder is 58 in. in diameter, with 10 ft. stroke, and works with 7 lb. to 8 lb. of steam pressure. The steam is supplied by six double-flued Cornish boilers, 10 ft. in diameter and 35 ft. long, and both the engines and boilers were constructed by a Scotch engineering firm, which ceased to exist many years ago. The condenser is placed below the steam-cylinder, and the blowing-cylinder stands at an equal radius of beam at the opposite side of the main centre. The blowing-cylinder has a diameter of 120 in. and a stroke of 10 ft. The speed of piston is, in both cylinders, 300 ft. per minute, giving, in round numbers, about 3000 cubic feet of air for each furnace per minute. This blast is heated to about 800° in hot-blast ovens of the "pistol-pipe" form, invented by Mr. Baird, and now very generally used in the Scotch ironworks. The stoves are fired with coal-slack, and are placed behind the furnaces at the level of the railways supplying the coal. Mr. Baird's original plan was to place the hot-blast stove on the top of his blast furnace, and to utilise the large flame escaping from the latter for heating the blast. Plans of that kind have been successfully introduced in Swedish and German charcoal blast furnaces; but at Gartsherrie this arrangement seems to have failed, and it was abandoned after some short experiments. The system of working resorted to, and the one universally followed in the ironworks of Scotland, is the charging of an abundance of raw coal along with very rich calcined ore and a small proportion of limestone, and wasting all the gaseous products of distillation and of partial combustion of the coal, which escape in the form of a large and brilliant flame at the top of each furnace. An independent and additional supply of coal is therefore required for firing the hot-blast ovens and the boilers for the blowing-engine and hoist, the material used for this purpose being the coal-slack or "dross" screened out of the coal as it is delivered at the pit's mouth.

The iron ore used at the Gartsherrie works is pure blackband, which is delivered from the mines in the calcined state, and an enormous store of which (we understand about 120,000 tons) is always kept on stock at these works. There is also a large stock of red hematite ore kept at Gartsherrie at this present moment, but this has been an exceptional purchase only, and does not enter into the current mixture of the blast-furnace charges. The calcination of the blackband ironstone is effected in open heaps of about 2000 tons of ironstone thrown up to a thickness of 5 ft. or 6 ft. and covered with small material all over the surface so as to exclude any excessive supply of air. The burning is effected in a similar manner to coking in open heaps; it requires constant care and attention, and occupies about three weeks for each heap of 2000 tons, if the calcination is carried on sufficiently slowly and uniformly to insure a good product. There is no fuel required for this process of calcination, as the blackband ironstone contains a sufficiency of free carbon for completely calcining itself. Before being charged into the blast-furnace, the calcined blackband ore is carefully assorted, and all visible pieces of impure matter and other admixture picked out by hand. It is the amount of care and attention bestowed upon this process of purification which constitutes the principal element in the maintenance of the high quality of the Gartsherrie brand. The workmen employed in the picking of ore are paid by the quantity of dirt which they remove, and this quantity, on the other hand, controls the quality of the original supply of ore delivered from the calcining heaps, there being a certain percentage of impurities allowed for each kind of ironstone, which, if exceeded, would subject the contractor at the ironstone mine to a fine. The iron ore, when carefully purified, is the richest iron ore now smelted in any locality. Its charge is about 32 cwt. to the ton of iron, as an average, and occasionally it comes even slightly below this figure. This very high percentage of iron in the ore at the same time reduces the demand for limestone to a very small quantity. There are two kinds of limestone used at Gartsherrie, both drawn from the coal measures at a very moderate expense. The charge per ton of iron made is 6 cwt. of pure limestone, or 10 cwt. of limestone containing a high percentage of alumina, which is occasionally preferred for forming a surplus of quickly melted slag. These charges are made up with the coal in quantities of about 30 cwt. each, and hoisted to the top of the furnace by a very simple arrangement. The cage is counterbalanced by a water-tub at the end of a chain, which works over a pulley at the top of the hoist, the water-tub, when filled, raising the cage and its charge, and when emptied at the bottom end of its course being overbalanced and raised in its turn by the descending cage. The water required for filling the tub is pumped into a large reservoir by a pump attached to the great blowing-engine. The furnaces are tapped every twelve hours, and produce each about 12 tons of iron at each cast. The weekly production of one furnace, including the stoppage on Sunday, gives an average of 160 tons. There are fourteen furnaces in blast at present out of the sixteen existing at Gartsherrie works, and their total make is about 120,000 tons of pig iron per annum. Of this quantity about eighty per cent. is "No. 1 Gartsherrie," or the standard quality of foundry iron known in the market, the rest being marked No. 2 and No. 3, and sold at a lower price. The production of forge pigs is only occasionally undertaken at these works, and this to special order at an exceptional price. The supply of coal for this great establishment is partly provided for by a coal-pit placed at a distance of about 150 yards from the furnaces. A very ingenious apparatus for hauling the coal-trucks from the pit's mouth to the screen, which latter is placed close to the furnaces, has been arranged by the late engineer of these works, under the superintendence of Mr. John Alexander, the principal manager of the Gartsherrie Ironworks. The trucks are moved in a horizontal direction by the winding-engine of the coal-pit, and simultaneously with the cages which go up and down the pit. The trucks with coal are sent forward to the screen and return empty to the pit's mouth, all movements being self-acting, so as to make the working of the pit coincide exactly with the transport of the coal in a horizontal line. The colliery belonging to this establishment has been for some time past the scene of numerous trials of coal-cutting machines of very different construction, an air-engine, very similar in every respect to that exhibited in Paris by Mr. Philander Shaw, and described in our columns, some weeks ago, being at work there for supplying compressed air to several of the machines working below ground with

this prime mover. Very little practical success has, however, attended these experiments as yet, and not one of the numerous schemes tried at this colliery for cutting coal by machinery has, up to this time, been sufficiently successful to be introduced for commercial working.

The large number of workmen employed at the Gartsherrie works (who, with their families, and with all the tradesmen employed by the wants of the latter, form a considerable population) stand in a much more suitable position to their employers than is found in the majority of works in England. The proprietors of these works, at an early date in the history of their establishment, considered it to be their duty, and to their advantage, to provide for the education of the rising generation of their workmen, and to see to the wants of those employed by them in a very liberal and comprehensive spirit. There are several schools maintained by the firm of Messrs. Baird and Company, and placed under the special supervision of Mr. Campbell, one of the managers of the Gartsherrie works. These schools, which accommodate a very large number of children of both sexes, and provide for a very complete elementary education of their pupils, stand in connexion with other educational establishments in the town of Coatbridge, where a more extended course of schooling may be obtained by the children of the *employés* of the Gartsherrie works at so moderate an expense that this system of education may be called, practically, gratuitous. There is, moreover, for any young man who shows particular talent and zeal for the pursuit of study a provision made by the liberality of this firm to afford to him the means of attending a college. There are several of the sons of Gartsherrie workmen who have been professionally educated in this manner now holding very respectable and lucrative positions in their native place and elsewhere. A co-operative store has also been established under the patronage of the firm for the benefit of their workmen. This store belongs entirely to the workmen, and is managed by a committee appointed by them. The articles are sold at comparatively moderate prices, and all purchasers participate in the profits to the proportion of purchases made by them at these stores. The profits realised are partly divided at the end of certain periods, and partly remain for constituting a sick-fund for the workmen, and a fund for pensions to the widows and orphans. It has been found by experience that these provisions very effectively prevent the workmen employed at Gartsherrie from joining trades' unions, and although they do not entirely destroy the effect of the great movements in the case of strikes and disputes, they still mitigate these evils and reduce their sad effects on both masters and men. With regard to this philanthropic and sensible way of establishing a direct interest and attachment between employers of labour and labouring men, the Gartsherrie works approach more closely to those large establishments on the Continent, of which we gave some accounts a short time ago, than any other works in England. This single instance affords a practical proof that most of the arrangements which have been found so eminently successful on the Continent are practicable in this country as well, and that their universal adoption would gradually, but without fail, abolish the present evils of trades' unions more certainly, more effectively, and in a more suitable manner, than any interference of legislature will be able to do.

COTTON.—The average weekly consumption of cotton in the United Kingdom was 46,850 bales last year, as compared with 39,180 bales in 1865. The average weekly deliveries from Liverpool to the trade last year were 45,460 bales. In the first nine months of this year the corresponding average was 44,910 bales.

THE FLORIDA AND CUBA CABLE.—It appears that the Spanish Government has accorded to the International Ocean Telegraph Company, which has laid down the Florida and Cuba cable, the exclusive right of establishing and working during a period of twenty years telegraphic lines between Cuba, the United States, and all other countries. Florida has given the company for the same space of time the privilege of constructing a land telegraph on the territory of that State. The Republic of Panama, and several of the colonial or independent Governments of the West Indies and South America, have guaranteed analogous favours to the company. It is proposed to carry a line from the northern frontier of Florida to the port of Cherrara, situated at some leagues to the west of Havana. Various branch lines are also contemplated. One of these will pass from the islands of Cuba, San Domingo, Porto Rico, St. Thomas, Guadeloupe, Martinique, and Trinidad, so as to terminate at Demarara, on the coast of Brazil. Thence it will be extended to San Roque, which a submarine wire will unite to the Cape de Verd islands, the coast of Africa, and Cadiz. Another line, commencing at St. Jacques de Cuba, will unite Jamaica and Aspinwall, and will be the means of putting the North of the American continent in communication with the Pacific coast. The works of this Aspinwall line are to be speedily commenced. General Smith, the director of the company's lines, is an old pupil of the military school of West Point.

RECENT PATENTS.

THE following specifications of completed patents are all dated within the year 1867; and that year should be given in ordering them, at the annexed prices, from the Great Seal Patent Office, Chancery-lane.

(No. 158, 8d.) William Arena Martin, of 90, Cannon-street, patents an apparatus for consuming smoke and feeding furnaces. This consists of a fire-door carried by a horizontal axis along the upper edge, the door being capable of being opened either inwards or outwards, so that it can be used for pushing fuel forward into the furnace, as well as for the admission of air. The coal is, in some forms of the apparatus, supplied from a hopper formed by the upper part of the casting to which the fire-door is fixed.

(No. 159, 1s. 2d.) Jean Chrétien, of 150, Boulevard Richard Lenoir, Paris, patents a form of steam crane in which the lifting-chain passes round a pulley, which is directly connected to a piston working in a long steam-cylinder forming the jib of the crane. One of M. Chrétien's steam cranes is now at the Paris Exhibition, and this crane was illustrated and fully described on pages 296 and 297 of our third volume.

(No. 161, 8d.) William Clark, of 53, Chancery-lane, patents, as the agent of Albert Philippe Adrien Accarain, of Outreaux, an arrangement of calcining or heating apparatus applicable to blast-furnaces worked with closed tops. As applied to a blast-furnace fitted with the "cup and cone" form of charging apparatus, the arrangement is as follows: The top of the furnace is provided with a cylindro-conical chamber, to the lower part of which the closing cone or bell is fitted in the usual way, whilst the upper part is surrounded by an annular pipe which is supplied with air by a fan or blower. From this annular pipe a number of short lengths of pipe or nozzles extend downwards to just above the junction of the chamber and closing cone, these nozzles having each two lateral holes at their lower ends, through which the compressed air can escape. This apparatus is used in the following manner: Supposing the furnace to have just been completely charged, and the cone to be closed, a proportion of flux is placed in the chamber, and over this a charge of ore, both the flux and ore being as equally distributed as possible. The closing bell is then lowered an inch or two so as to allow the waste gases to pass up up into the chamber, where, being met by the air from the nozzles, they ignite and effect the heating of the charge of ore and flux. When the furnace has to be re-charged, the blast is shut off from the nozzles, the closing bell is raised, and a charge of fuel is placed upon the heated materials in the chamber. The closing bell is then again lowered, and the contents of the hopper discharged into the furnace in the usual way.

(No. 165, 10d.) Henry Bridgewater, of Watford, patents improvements in the construction of railway turntables. This patent refers to peculiarities in the constructive details which could scarcely be clearly explained without reference to drawings.

(No. 173, 10d.) Joseph Standing Dronsfield, of Oldham, patents a machine for grinding "card" rollers and cylinders, the main feature of this machine being the arrangement employed for moving the "card" roller to or from the emery-covered grinding roller. According to this plan, the axes of the roller which is being ground are mounted in bearings carried by arms fixed on a transverse shaft beneath the roller, this shaft being capable of having an oscillating motion imparted to it by worm gearing, so that the "card" roller can be approached to or removed from the grinding roller, and at the same time kept with its axis parallel to that of the latter.

(No. 178, 1s.) Fitzmaurice Palmer, of Old Derrig, Queen's county, patents some war vessels of fearful and wonderful form. These vessels have a midship section, the outline of which greatly resembles that of the urns which were at one time so largely used by architects for decorative (?) purposes. The resemblance is increased by the keels being provided with bottom flanges of a width equal to about half that of the vessels themselves!

(No. 193, 10d.) Thomas Berney, of Bracon Hall, Norfolk, patents what we fear is an impracticable form of armour for vessels, forts, &c. This armour consists of white or spathic cast iron run into wrought shells so as to form blocks which are packed together over the surface to be protected, and are secured by bolts screwed into sockets formed on their bases. The blocks are also connected by joggles formed on their sides. A system of backing for these blocks, and some forms of bullet-proof shields for portholes, are also included in this patent, in which it is stated that the space behind the backing may be filled with water

"so as to assist in spreading the impact of projectiles 'over a larger area.'" We presume that the idea was thus to get a moderate pressure over a large area in place of an intense pressure on a small one; but if Mr. Berney had studied the laws of hydrostatics, he would have known that no such end could be obtained by the means proposed, the pressure transmitted by the water being equally intense in all directions, and being equal in intensity to that imposed upon it by the action of the shot.

(No. 196, 10d.) William Gray, of the St. Phillip's Works, Sheffield, patents an arrangement of rolls for producing ribbed bars. According to this plan, a steel disc or collar on the upper roll is arranged to work into a corresponding groove in the lower roll, this disc or collar having a number of teeth or ribbed projections formed on its periphery. The bar, passing between the edge of the disc and the bottom of the groove in which it works, is notched or indented on its upper surface, and the arrangement can thus be used for producing toothed bars for the beaters of thrashing-machine, lathe-racks, &c.

(No. 208, 10d.) Peter Jensen, of 4, Gordon-grove, Holland-road, Brixton, patents, as the agent of Carl Vilhelm Schröder and Frederick Julius Jørgensen, of 108, Vesterbrogade, Copenhagen, the arrangement of "roller-and-worm" gearing, of which, as applied to a horse-wheel, we gave an engraving and description on page 309 of our last number.

(No. 220, 1s. 8d.) Charles Wheatstone, of 19, Park-crescent, Portland-place, patents various improvements in electric telegraph apparatus. This specification will be of interest to electricians, but the various details claimed in it are too numerous for us to even enumerate them here.

(No. 221, 1s. 10d.) Eric Hugo Waldenström, of Manchester, and Isaac Gray Bass, of Worthington, patent an arrangement of bolt-making machine, to describe which, without reference to drawings, would require more space than we can give it here.

(No. 228, 1s. 10d.) George Haseltine, of 8, Southampton-buildings, patents, as the agent of Samuel Whitford Tyler, of Troy, U.S., a machine for pulling flax and similar crops, this machine taking up the crops by the roots and depositing them so that it can be conveniently bound into sheaves.

(No. 230, 1s.) François Constant Cambrelin, of Brussels, patents an arrangement of apparatus for lighting railway-trains with gas. The patent refers to numerous points of detail which we cannot describe here.

(No. 233, 8d.) Alphonse Donnet, of Lyons, patents a method of obtaining an increased supply of water from wells by exhausting the air from them.

(No. 235, 4d.) John Hopkinson, of Leeds, patents the use of jets of superheated steam for producing an upward current in the up-cast shafts of mines. The employment of jets for ventilating purposes in this manner is far from new; but we cannot say whether the steam so used has been highly superheated, or whether means have been previously adopted for drying the air, as Mr. Hopkinson proposes, for the purpose of maintaining the steam in an anhydrous state until it has completely escaped from the shaft.

(No. 243, 1s. 2d.) William Edward Newton, of 66, Chancery-lane, patents, as the agent of Adrien Houget, Emile Bede, and Laurent Roufosse, of Verviers, Belgium, an apparatus for feeding steam boilers and indicating the quantity of water supplied to them. This apparatus could not be described without reference to drawings.

(No. 244, 8d.) William Edward Newton, of 66, Chancery-lane, patents, as the agent of Nicholas Pooteloff, of St. Petersburg, a method of casting articles in two kinds of metals, such as steel and cast iron, combined so that part of the article, when cast, may be hard and the rest soft and tough. If it be required to make part of an article of hard cast iron, and the remainder of soft or Bessemer steel, the two metals are melted simultaneously in separate crucibles; and when they are ready for pouring, one of them, say the cast iron, is poured first into the mould, and then the other. The patentee states that a perfect junction of the two metals is formed in the mould; but we should think that considerable experience in the use of the process would be necessary to ensure a thoroughly reliable result.

(No. 255, 8d.) Bristow Hunt, of 1, Serle-street, patents, as the agent of Joseph Summers Wood, John Jackson Carberry, John Baker, junior, and Oscar Dunreath McClellan, of Philadelphia, a form of gas-regulator or governor, the peculiarities of the apparatus consisting in arrangement of the inlet and discharge pipes, and in some other details.

(No. 261, 2s. 2d.) Charles William Siemens, of 3,

Great George-street, Westminster, patents arrangements for producing electric lights at sea, and other electrical apparatus. The apparatus for producing the electric light—which is applicable to the illumination of buoys, &c.—was described in a paper read before the British Association on the occasion of their recent meeting at Dundee. This paper was published on page 196 of the present volume of *ENGINEERING*.

(No. 267, 10d.) John Henry Johnson, of 47, Lincoln's-inn-fields, patents, as the agent of Albert Schmid, of Paris, some details in the construction of traction engines. The claims include guiding the engine by a single wheel in front, the wheel being carried by bearings at the lower end of a vertical shaft, which can be turned by a hand-lever. Another point claimed is the discharge of the blast into a superheating-chamber in the smokebox, from which chamber it is allowed to escape continuously; and another detail is a kind of differential motion for working the driving wheels and allowing them to revolve at different speeds when the engine is being turned. We fear that there is very little, if anything, that is new in all this.

(No. 269, 1s. 4d.) Edward Thomas Hughes, of 123, Chancery-lane, patents, as the agent of Henry Bascom Brown, of New Haven, U.S., a screw cutting-machine, the construction of which could not be explained without reference to drawings.

(No. 271, 2s. 2d.) David Alexander Halket, of Newcastle-on-Tyne, patents an ingenious but somewhat elaborate machine for making nails and spikes. As in the case of the patent last noticed, it would be impossible to clearly describe this machine without reference to drawings.

(No. 277, 10d.) George Russell, of Glasgow, patents working the swinging or sluing gear of steam and other cranes by means of an endless chain or band passing over suitable pulleys. The chain or band is kept tight by means of weights or springs, the tension being adjusted so, that although the chain has sufficient grip to work the sluing gear under ordinary circumstances, it will yet slip if the crane is accidentally checked whilst the sluing motion is in gear. A crane fitted with chain-gearing of this kind is exhibited by Messrs. Russell, at Paris, and it was described by us on page 269 of the third volume of *ENGINEERING*.

(No. 278, 10d.) Isham Bagges, of High Holborn, patents obtaining motive power by means of the generation and expansion of hydrochloric acid gas, which latter is applied to drive a suitable engine. The gas is generated by bringing a solution of it in contact with sulphuric acid, and it is condensed after it has performed its work, by passing it through a receiver containing water.

(No. 290, 10d.) John Gilbert Robinson, of the Ainley Fireclay Works, Elland, patents the application to kilns and ovens, for burning bricks, pottery, and other articles, of an annular flue in the floor of each oven, and of a system of connecting flues for enabling the waste heat from one kiln to be utilised for drying or warming the others.

LOCOMOTIVE FOR THE FESTINIOG RAILWAY.

We give, on the next page, engravings representing a longitudinal section and plan, together with end-elevations and transverse sections, of one of four small locomotive engines, designed and constructed by Messrs. George England and Co., for the Festiniog Railway—a line remarkable for the extreme narrowness of its gauge, which is only 2 ft. The Festiniog Railway was commenced in 1832, its construction having been undertaken under several peculiar conditions by a company incorporated in that year. The objects of the line were stated to be to open out "a more direct, easy, cheap, and commodious communication between the interior of the principal district of slate and other quarries of the county of Merioneth and the various shipping-places at and within the said several counties of Carnarvon and Merioneth;" and to "greatly facilitate the conveyance of coals and other heavy articles to the several slate and other quarries and mines in the said district, and the conveyance of the slate, copper, and other ores, and other productions of the said slate, and other quarries and mines, and of the surrounding country, to the 'seaside;' and that it should be in other respects 'a work of great public utility.'" Amongst other restrictions imposed upon the company, it was determined that all the steam-engines employed on the line should consume their own smoke; that no lands taken or used for the purposes specified in the company's Act were to exceed four yards in width, except where it was necessary for carriages or wagons to "turn, remain, or pass each other," or where buildings, wharves, goods stations, embankments, or cuttings had to be erected or constructed; and that no work or building was to exceed 60 yards in width at any place, except on commons or waste lands, or by consent of owners. The company was also not to occupy more than was absolutely necessary of the Traeth Mawr embankment, near Portmadoc; the gauge of rails on that embankment was not to exceed 3 ft.; the surface of the embankment was not to be disturbed more than 1 ft.; and the ordinary traffic upon it was not to be interrupted.

The line, which is between thirteen and fourteen miles in length, and runs through a hilly and extremely picturesque country, commenced at a quay near Portmadoc, in the parish of Ynys-cynhainain, in Carnarvonshire, and ended at the Rhiwtrydwr and Duffws slate quarries, in the parish of Festiniog, in the county of Merioneth. In 1832, when the company was formed, the district through which the railway was to pass was but thinly populated, and, with a view to economy, the line was constructed as a horse tramway of the very narrow gauge of 2 ft. The estimated cost was 24,185*l.* 10*s.*, and the company was authorised to raise 10,000*l.* by loan. Eventually the company was authorised to raise further sums of 12,000*l.* and 4000*l.*, the former by shares and the latter by loan, the total Parliamentary capital of the company being thus increased to 50,185*l.* 10*s.*

As at first constructed, the curves and gradients on the Festiniog line were very severe; but, as the traffic increased, improvements were, from time to time, made in this respect, in some cases at considerable expense. Between the terminus at Portmadoc and the mountain terminus at Dinas there is a difference of level of 703 ft., and the average gradient for a distance of 12½ miles between the latter terminus and the Traeth Mawr embankment, at Portmadoc, is 1 in 92. The steepest gradient on which locomotive engines are employed is 1 in 60, and on that portion of the line used for passenger traffic the steepest inclination is 1 in 79.82. The curves have radii varying from 4 chains to as little as 2 chains, the maximum super-elevation of the exterior rail on curves of the latter radius being 2½ in. for a speed of eight miles per hour. The line is at present laid with rails weighing 30 lb. per yard, and in lengths of 18 ft. and 21 ft., these rails being supported by cast-iron chairs, secured by 4½ in. spikes to larch sleepers. The joint chairs weigh 13 lb., and the intermediate chairs 10 lb. each, and the sleepers are 4 ft. 6 in. long, and average 10 in. wide by 5 in. deep under the joints of the rails, and 4 in. by 4 in. elsewhere. The sleepers on each side of the joints are placed 1 ft. 6 in. apart, and they are 2 ft. 8 in. in the intermediate spaces. The railway passes through two tunnels, one of these being 60 yards long, through hard shale, and the other 730 yards long, through syenite rock sufficiently solid to require no lining. Amongst the other works on the line are seventeen under and five over bridges, the latter being for foot-passengers only, and, besides these, there are numerous stone viaducts over valleys. Most of the smaller openings are spanned by heavy slabs of slate.

As the slate quarries are situated at different elevations, the slates are first brought down the quarry inclines to the railway, and the trucks are then made up into trains which are allowed to run down to Portmadoc by the force of gravity, and in charge of brakemen. These trains consist of from fifty to sixty trucks each. Up to the year 1863 the return trains, consisting either of empty trucks or of trucks containing coals, goods, or materials for the quarries and neighbourhood were drawn up by horses which were conveyed to Portmadoc in the down trains. Eventually, however, the traffic increased so much that it became advisable to substitute steam for horse power, and after considerable discussion as to the possibility of successfully employing locomotives on a line of such narrow gauge, Mr. England was employed under Mr. Spooner, the secretary and engineer to the company, to design and construct an engine suitable for working the traffic. The result was the placing on the line, in 1863, of two engines on the plans which we now illustrate, and these engines were found to perform their duties so efficiently, that they have since been supplemented by two others of the same construction.

As will be seen from our engravings, the engines have two pairs of coupled wheels, these wheels being 2 ft. in diameter, and being placed under the barrel of the boiler at a distance apart of 5 ft. from centre to centre. The cylinders, which are outside, are 8 in. in diameter, with 12 in. stroke, and the connecting-rods take hold of crank-pins in the hind pair of driving wheels. The frames are inside, and the two steam chests of the cylinders meet under the smokebox, and are bolted together, a plan which greatly stiffens the front end of the engine. The boiler, which is worked at the high pressure of 200 lb. per square inch, contains 140 brass tubes, 1½ in. in diameter outside, and 7 ft. 8 in. long, these giving an external surface of 365 square feet, making, with a firebox surface of 22 square feet, a total heating surface of 377 square feet. The firegrate has an area of 4 square feet. The link motion is of Allan's straight-link kind, arranged as shown in the sections. The feed water is carried in a saddle tank covering the top and sides of the boiler, this tank being capable of containing 414 gallons. The boiler is fed by a pair of Giffard's injectors. The small quantity of coal required by each engine is carried on a four-wheeled truck attached to it, the truck serving as a tender. The heaviest of the engines weighs about 7½ tons in working order, and their cost was about 900*l.* each.

The designing of an efficient and, comparatively speaking, powerful engine to work on a line laid to such a narrow gauge as 2 ft. presents considerable difficulty, and Mr. England deserves much credit for the manner in which he has accomplished the task in the case of the engines we have described. Mr. England has had great experience in the construction and working of small locomotives, and when, in 1862, parliamentary powers were being attempted to be obtained to allow of the Festiniog line being widened to 4 ft. 8½ in. gauge, he strongly recommended in his evidence before the committee that such engines should be adopted on the 2 ft. gauge. This was in opposition to the opinion of the late Mr. Robert Stephenson, who, writing to Mr. Spooner, the secretary of the company, on the practicability of using locomotives on so narrow a gauge, had said, "The thing is impossible." The widening of the line was strongly opposed by Mr. Spooner, and eventually the Bill was thrown out, and powers granted to the company to work the 2 ft. gauge line with locomotives.

Mr. England, when applied to to design the engines, guaranteed that they should take a load of 25 tons gross over the line at the speed of ten miles per hour; but their actual performance has greatly exceeded this. The average load taken up by each engine in regular work on the ascending journey,