ON THE APPLICATION OF THE SPECTROSCOPE TO THE ANALYSIS OF IRON AND STEEL.—No. III.

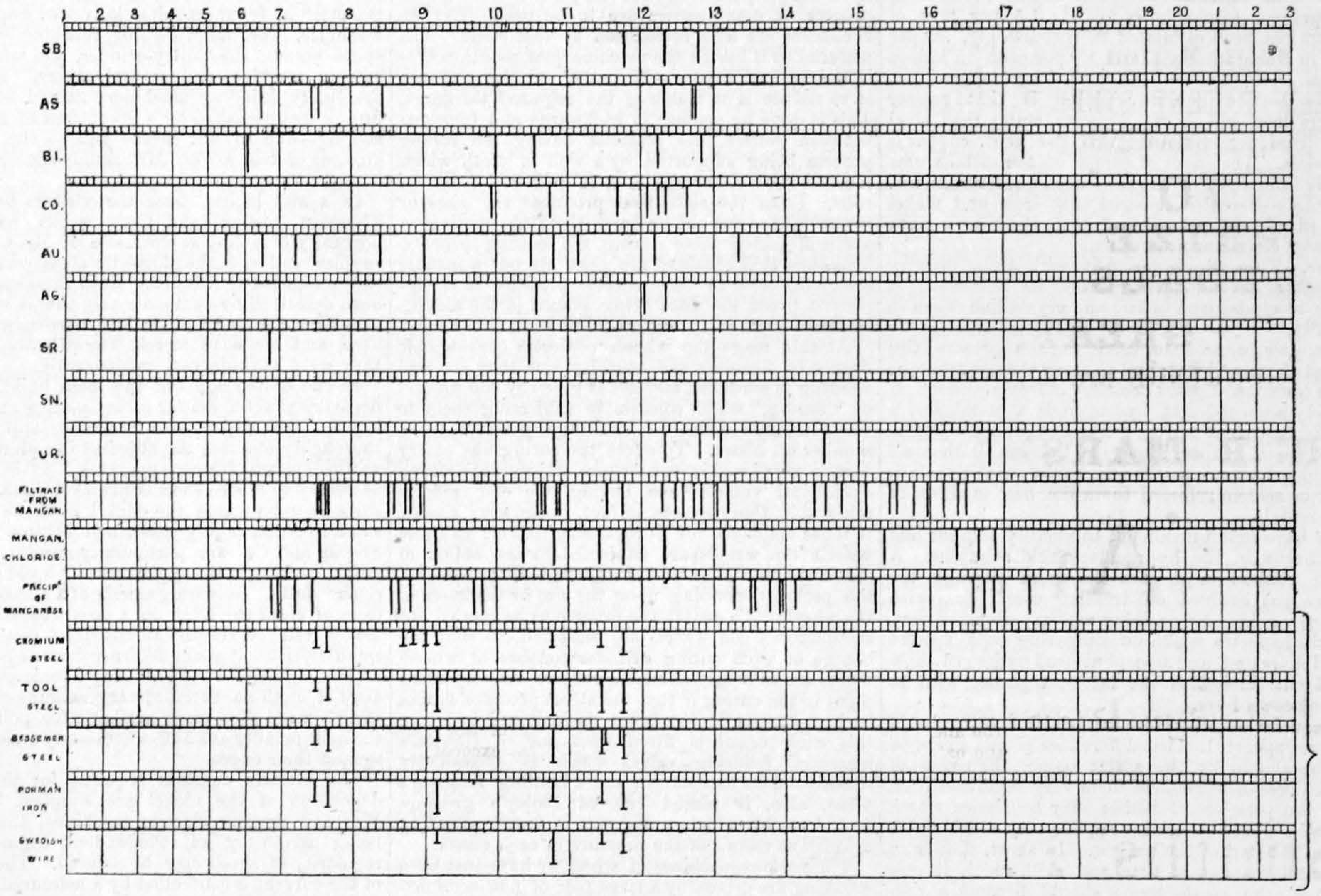
By John Parry, F.C.S., and Alex. E. Tucker, F.C.S.

1. We now give the principal characteristic lines of nine other elements, viz., Antimony, Arsenic, Bismuth, Cobalt, Gold, Silver, Strontium, Tin, and Uranium. The chlorides of these metals were prepared when possible from the metals themselves. These nine render the list somewhat complete as regards such metals as may fairly be looked for. It has not been thought necessary to show any but the characteristic lines.

The following five spectra are those referred to in our last article*: 1. Chromium steel; 2. Tool steel; 3. Bessemer steel; 4. Assay button from Porman ore; 5. Swedish wire used in standardising assay solutions. Here also, in order to render the matter clearer, those lines only are shown in which differences occur, all other lines appearing common to the spectra. These differences are sufficiently marked to be easily seen, and, since we have found them constant, they render the spectra characteristic. We therefore obtain the result: That some varieties of steel may be recognised by the aid of the spectroscope. The differences in the spectra are detailed as follows: Chromium steel shows the chromium lines, and seems deficient in manganese. Tool steel seems to contain more calcium and Swedish wire less calcium than the others. Bessemer steel shows the aluminium lines at 4.5 and 6.5. Porman iron exhibits two lines about 7.7, which are fainter than those of other steels, and the manganese stands out prominently.

The statement of Dr. Miller that the spectrograph of a substance is a constant not less important than its specific gravity or fusing point, is thus applicable to iron and steel and iron ores. We have no doubt that the systematic comparison of steel spectrographs of unknown composition with standard spectrographs must eventually be of considerable utility, and the importance of the above result will, we think, be recognised by those interested in the obscure differences of irons and steels which otherwise may show similar chemical composition. We again express our regret that it has not been possible to reproduce the original photographs, for it is at best unsatisfactory to represent the position of these lines by hand work, and it is certainly next to impossible to represent their exact differences of intensity. On examining these original spectra with a magnifier there can be no doubt that the differences would be more numerous and more marked were a higher power than one prism used in the spectroscope.

* See Engineering, vol. xxvii., page 429.



Lockyer states that even when the percentage of a constituent in an alloy is so small that none of its lines can be recognised, there yet seems to be an effect on the lines of the other constituent of which the alloy is chiefly composed; the lines also vary in length, in thickness, and brightness as the percentage of one or other constituent in the alloy varies.*

2. Three principal methods for the separation of iron from the looked-for bodies have been tried. In each case the supposition kept in view was that the physical influence of mass prevented the separation; our efforts were, therefore, directed to avoiding or lessening this influence.

a. We have tried that given by Hannay (*Journal of the Chemical Society*, June, 1878). When a solution of manganous salt in strong nitric acid is warmed with addition of crystals of potassic chlorate, the whole of the Mn is precipitated as manganous manganate. When a salt of iron is present the Mn is still precipitated, but in combination with the iron as double manganate of iron and manganese; no other metals are precipitated.

To test this method we added a few drops of a solution containing calcium, cobalt, copper, cadmium, and zinc to another of Bessemer steel, and in the solution eventually obtained we found all five elements. The process is, however, difficult when considerable quantities of steel are operated upon.

b. We treated the gently dried impure perchloride of iron obtained on evaporating the hydrochloric acid solution of a Bessemer steel to dryness with sulphide of ammonium, the sulphides of tin, antimony, and arsenic being soluble therein, we hoped by this method to obtain evidence as to the presence of these bodies; the results were of a negative character, the solution, however, on examination showed distinct indications of either arsenic or antimony, in our opinion the latter.

* In gold copper alloy an increase of 1000 part of gold alters the lines, silver copper alloy by increasing either the copper or the silver a corresponding alteration in the lines is produced; after registering these facts the phenomena may be explained by assuming in fact that alloys differing, say, by 1000 part, are physically different things, and it is probable the spark acts on the alloy as a whole as well as upon each vapour separately.

c. Positive results have been obtained in the following experiment: About 300 grains of Bessemer steel were dissolved in aqua regia, the solution evaporated to dryness over a paraffine bath, much perchloride was reduced to peroxide. The residue was heated more strongly over a Bunsen lamp, and the sublimate collected on a porcelain plate. The residue and sublimate were mixed and treated, with (*a*) water and long boiled and filtered, (*b*) ammonia and long boiled and filtered, (*c*) acetic acid and long boiled and filtered. The three solutions contained much iron, chiefly, from deficiency at first of nitric acid, in the state of protoxide. The solutions were therefore separately oxidised with nitric acid, and the iron partially separated in a very acetous solution in *a* and *b*; *c* was boiled for a long time, and its iron thus also partially removed. When the iron had been wholly removed by second precipitation in the three solutions separately, they were mixed and the resulting liquid filtered and treated with much nitric acid to decompose ammoniacal salts. The solution was now a fine olive green colour, which lightened in tint on continuing the decomposition, the nitric acid was replaced by hydrochloric acid, solution again well boiled, and then photographed. From the first photograph taken it was evidently advisable to eliminate the manganese. This was accordingly done, and the precipitate of manganese and the filtrate examined separately. From these solutions plates showing the lines given in spectra 11 and 12 have been taken, and we have succeeded in recognising in them the elements aluminium, arsenic, calcium, copper, nickel, and zinc. The coincidences may be seen from Diagram 1 (page 429, vol. xxvii.). The negatives show other lines, which at present we have not been able to recognise.

A few remarks on the influence of the above metals may be of service. Aluminium, according to Deville, unites in all proportions with iron. Faraday found from .01 to .06 per cent. of aluminium in Wootz steel. In consequence, the excellent qualities of Wootz were ascribed to its presence, and attempts made to produce aluminium steel. Analyses, however, by Rammelsberg and others showed that the metal produced contained only traces of aluminium. From 0.5 to 1 per cent. has been found in English, 0.75 in Swedish, and 0.77 in

Siegerland pig. Karsten while questioning the habitual reduction of alumina in ordinary blast furnaces, expresses his opinion that in the event of its alloying with iron, it must very considerably lessen the toughness (Festigkeit) of the latter, since very cold short (faulbrüchigen) merchant bar invariably shows the most aluminium.*

Arsenic has been frequently recognised in iron and steel, and has been alloyed as high as 70 per cent. Analyses of some cannon balls from Sinope showed 16 per cent. arsenic, others, bombs and shot, showed 9 and 27 per cent. respectively, and were supposed to have been cast in Spain, their age was not known. As cast iron they were quite worthless.

Calcium.—Karsten found 0.17 per cent. of calcium in an iron which, although neither red nor cold short, refused to weld. This iron had been puddled with limestone. The general opinion is, we think, that limestone used in fettling renders iron red short; this result, however, cannot determine the influence of calcium on iron as an alloy, it existing here perhaps mechanically mixed; 1.5 per cent. of calcium has been estimated in Swedish pig, .25 per cent. in Könighutte pig, and .09 per cent. in Müsen spiegel.

Copper.—The general opinion is that copper renders iron red short. Eggertz states that steel made from pig containing 0.5 per cent. copper is worthless. The effect of copper on the metal seems largely influenced by the presence of other elements.

Nickel.—Berthier remarks that iron and nickel alloy in all proportions, and that the alloys have the same character as pure iron.

Zinc.—Zinc alloys variously with iron, no very satisfactory accounts are given of its influence; it seems to render iron brittle and crystalline when in quantity.

We now propose to leave for the present this branch of our subject, and to apply the spectroscope to the question of gases occluded in iron and steel. It is freely admitted that hydrogen is a metal, and is invariably present in iron, but although, according to Van Troost, Müller, Parry, and others, both steel and spiegel often contain weighable quantities, it is never or seldom referred to in the best analyses of these metals.

We have found it difficult to identify sulphur and phosphorus in the hydrochloric acid solutions. A better method is to pass the spark through the impure gas evolved on treating steel, &c., with sulphuric acid. By so doing we have obtained very beautiful spectra which on comparing with spectra of sulphuretted and phosphuretted hydrogen show coincident lines with the latter, together with as yet unknown lines.

In conclusion, therefore, we claim to have shown in these papers: 1. That differences in iron and steel may be shown by the spectroscope, the nature of which differences renders them very significant. 2. That the presence of bodies may be shown whose detection would otherwise require very considerable skill on the part of the analyst. In short, that from the small amount of time and skill which its use involves, the spectroscope should become a *vade mecum* of every iron works laboratory.†

THE INSTITUTION OF MECHANICAL ENGINEERS.

We now append some further notices of works visited by the members of the Institution of Mechanical Engineers during their recent meeting at Glasgow, the demands upon our space last week having compelled us to defer these notices until our present issue.

The Crown Iron Works, Glasgow; Messrs. Thomson, Sterne, and Co.

The Crown Iron Works of Messrs. Thomson, Sterne, and Co. were amongst the most interesting of the establishments thrown open to members of the Institution of Mechanical Engineers during the recent Glasgow meeting. The chief productions of the firm are, as is well known, emery wheels and grinding machines in which emery wheels are used, and helical springs of various kinds; to these they have more recently added the construction of hydrocarbon and gas engines. An important department is also devoted to nickel-plating. The works are situated on the North Woodside-road, Glasgow, and they are especially noticeable for their good design and arrangement, and for the neatness and completeness of their equipment.

The manufacture of emery wheels is carried on in the basement story of the main block of buildings. The class of wheel made by the firm is the well-known "Warne" wheel, and the processes of manufacture are interesting. The first process consists in mixing in a suitable machine by means of powerful rollers, the materials which form the body of the wheel and give it its coherence, this material consisting chiefly of india-rubber having fibrous matter embodied in it. Next the materials so mixed are passed on to a second machine of a similar character in which the emery is added, the fineness or coarseness of the emery of course depending upon the purpose for which the particular wheels in process of manufacture are to be used. Certain chemicals are also introduced at this stage. The material as it leaves the machine just mentioned is in the form of a very stiff paste, and the next step is to reduce it to a slab of the required thickness. This is done by passing it backwards and forwards between rollers, the material during the rolling process being supported by a web of cloth which receives it on either side as it is delivered from the rolls. From the slabs thus produced the discs or "wheels" are cut out by hand, the slabs resting on a steam-heated table during the cutting process. The discs thus obtained are next placed in moulds and subjected to very severe pressure in a hydraulic press, the discs being placed in the moulds in pairs.

At this stage the wheels possess a considerable degree of firmness and tenacity, but they are still wanting in hardness, and this is given by the process of "curing," which consists in subjecting them to the combined action of heat and pressure for a number of hours. To effect the curing the emery wheels are placed in iron wagons and run into strong cylindrical vessels each having one end readily removable, these vessels, in fact, being very similar to those employed for Burnettising timber. In these vessels the wheels are subjected to the action of steam at about 45 lb. pressure for a number of hours, the period depending upon the size or thickness of the wheels. To enable the process to be carried out satisfactorily the wheels are classified, so that the charge of each curing cylinder consists of wheels which are as nearly alike as possible. An important point in the curing is that the steam pressure should be kept exactly at the point desired, and to insure this each vessel is fitted with one of Hanson's mercurial reducing valves which is exceedingly sensitive in its action. In the adjoining foreman's office, also, is placed one of Bailey's pressure recorders, by which a diagram is drawn affording a constant record of the pressure in each vessel.

The various machines of which we have just been speaking are driven by a large pair of non-condensing engines, which also give motion to machine tools in the floors above.

The plant required for the production of emery wheels by the process used by Messrs. Thomson, Sterne, and Co., is of a massive character, and requires very considerable power to drive it, but, on the other hand, it has great powers of production, and turns out wheels of a most trustworthy kind. It will be unnecessary that we should enter here into any discussion of the merits of emery wheels, but we may allude in passing to the enormous variety of wheels which Messrs. Thomson, Sterne, and Co. produce, these varying from the small, apparently delicate, wheels required for some classes of finishing work to the heavy slabs suitable for trimming castings and rough work generally.

The plant for the production of the emery wheels occupies, as we have said, the basement of the main block of building; the floor above is devoted to machine tools employed in the production of the various grinding machines in which emery wheels are used, and also in the construction of gas engines. All who are familiar with the emery grinders made by Messrs. Thomson, Sterne, and Co., well know that one of their distinctive features is the neat design of the frames or bedplates. These frames are machine moulded, and in the department of which we are now speaking some excellent samples of these castings were to be seen. Messrs. Thomson, Sterne, and Co. also fit their grinders with very long cast-iron bearings, the bearing bushes being turned externally to fit correspondingly bored seats in the machine standards. With the very high speeds at which the spindles of these machines are run it is especially desirable that these bearings should be thoroughly true, and hence the plant in the department with which we are now dealing includes special means of carrying out this part of the work.

The floor above that of which we have just been speaking is also partly devoted to machine tools and to the erection of emery grinding machinery, the whole of the work being thoroughly sectionised, while still higher is a store or show-room provided with shafting, so that the machines may be run and tested. The emery grinding machines constructed by Messrs. Thomson, Sterne, and Co. are, as our readers are aware, of a very varied kind. They include not merely a large range of sizes of the so-called "grinders," but also a number of special machines fitted with appliances of a more or less automatic character, and in which emery wheels are used. Such, for instance, are the twist-drill grinder, the machine for sharpening knives of paper-cutting machines, the machine for finishing Kennedy's spiral punch, the pulley-grinder, the wheel tooth-cutting machine, and several others. Altogether the emery grinding machinery turned out by this firm is distinguished by a great deal of special designing—due to Mr. Sterne and to the managing director of the works, Mr. Handyside—and hence it is of corresponding interest.

In a still higher floor the visitors to Messrs. Thomson, Sterne, and Co.'s works had an opportunity of seeing at work one of Mr. Clerk's gas engines, and also the domestic steam motor which they exhibited at Kilburn. Both these engines have been described by us so recently that it will be unnecessary for us to enter into particulars of them here, and we need merely record, therefore, that they were working very satisfactorily.

In one of the floors of the main building is the department set apart for nickel plating and electrotyping, this department including appliances for thoroughly cleaning the objects to be plated, as well as the electro-plating apparatus. It is especially necessary to insure successful nickel plating that the surfaces upon which the nickel is to be deposited should be thoroughly clean, and Messrs. Thomson, Sterne, and Co. are particularly careful upon this point. Amongst the appliances employed is an American "dolly," consisting merely of a number of loose discs of cloth threaded on a boss which is made so that it can be readily mounted on one end of a spindle driven at about 2000 revolutions per minute. At this high speed the centrifugal force gives to the discs of cloth an extraordinary amount of rigidity, and they are thus made available for polishing—in the same manner as a buff-wheel—any article pressed against their edges.

The electric currents required for the electro-deposition of the nickel are supplied by one of Weston's dynamo-electric machines, this machine being driven by an independent engine, so that regularity of speed may be secured. The strength of the current is controlled by a mercurial governor.

We have said that the large engine in the basement of the main building drives also the machine tools on the floors above. Each floor is, however, also provided at one end with a pair of diagonal wall engines, having their crankshafts capable of being coupled direct to the shafting; these engines being available in the event of a failure of the main engine, or one floor alone has to be worked extra hours. One of these wall engines also drives the dynamo-electric machine already mentioned. In the building with which we have been dealing each floor constitutes a distinct department, with its own foreman, and the staircase being contained in a kind of tower with landings opening to each floor, there is no occasion for the men employed on one floor to traverse the other floors. A large hoist gives the necessary facilities for the transport of materials and finished work to and from the several floors.

We must now speak of the spring department, which consists entirely of one-story buildings. In addition to plain helical springs of various kinds, Messrs. Thomson, Sterne, and Co. are makers of such springs packed with compressed wool and with india-rubber, and special machines are provided for inserting these cores. For coiling the helical springs two different machines are employed. In the one used for small springs, the steel bar uniformly heated in a suitable furnace is seized at one end by a convenient holder attached to a spindle to which rotary motion is subsequently given, the bar being thus coiled on a suitable mandrel carried by the

* "Die Metallurgie," von J. Percy, F.R.S, übertragen u. bearb, von Drn. Knapp u. Wedding, 1865.

† We have prepared carbon points from loaf sugar as suggested by us in our last paper. The sugar is carbonised in a clean and large porcelain crucible, the coke thus made is powdered and damped with weak syrup and pressed, the mass is then coked and sawn into suitable pieces. These carbon points leave no perceptible ash on ignition. We consider that when pure carbon is required this method of preparing it is excellent.

spindle, while the pitch of the helix formed is determined by a correspondingly screwed cylindrical guide which is mounted on a mandrel parallel to that on which the coiling is taking place. For a right-handed spring the thread cut in the guide is left-handed, and *vice versâ*, the effect being that as the guide and the spring in course of formation revolve in contact, the former constitutes a kind of partial nut for the latter and determines the pitch at which the coils are placed. In the other machine which is used for coiling large springs, and springs differing from the standard sizes, the revolving guide is dispensed with, the pitch of the coils being determined by a gauge hooked on the coiling bar. Messrs. Thomson, Sterne, and Co.'s arrangements for the manufacture of these helical springs are altogether very complete, and include many appliances into the details of which it is unnecessary to enter here. Adjoining the spring department is the japanning shop, where the japanning of a number of the goods which the firm produce is carried out. A large quantity of the helical springs are finished in this way, but others, such as those intended for marine safety valves, are either nickel-plated or electrotyped with copper.

Besides the helical steel springs, Messrs. Thomson, Sterne, and Co. are also manufacturers of Mr. Sterne's india-rubber springs, so largely used for buffer and draw-springs, the distinguishing feature of which is that the india-rubber rings which constitute them, are during the process of manufacture firmly secured to the steel plates which separate them. So firm is this union that in tests made to determine the soundness of the attachment, the rings have torn through the body of the india-rubber rather than part from the plates. In connexion with these springs we may mention that the steel discs or division plates for them are punched out by a machine fitted with a kind of spiral die acting on the same principle as Kennedy's spiral punch already noticed in our pages, and of which the firm are makers. Adjoining the machine used for this work is the range of Lancashire boilers by which the various engines are supplied with steam, the equipment of these, like everything else about the works, being a model of neatness.

Besides the departments of which we have already spoken the works include a well-equipped smithy, a pattern shop, and a foundry, &c. There is also a small shop devoted to pulley grinding, Messrs. Thomson, Sterne, and Co. finishing all the belt pulleys for their machines by means of a grinding machine similar to that which they exhibited at Paris last year, and which we illustrated on page 443 of our twenty-fifth volume. The machine does its work well and quickly. In the pattern shop at the time of our visit the patterns for the latest design of Clerk's gas engine were in progress. This engine is marked by several important improvements in detail as compared with that exhibited at the Kilburn show, and we shall have more to say about it on a future occasion. The foundry work done at the Crown Iron Works is excellent, a specialty being the production of small castings which fully equal any we have seen from the other side of the Atlantic—and in this particular class of work it is impossible to give higher praise. There are in fact a good many Transatlantic features about Messrs. Thomson, Sterne, and Co.'s works, the firm having incorporated American and English mechanical engineering practices in a way that renders a survey of their works particularly interesting and instructive.

ST. ROLLOX LOCOMOTIVE WORKS; CALEDONIAN RAILWAY COMPANY.

The locomotive works of the Caledonian Railway Company were first established in Greenock in the year 1846, and placed under the superintendence of Mr. Robert Sinclair, the first engine built being one for passenger traffic on the Barrhead line. It was turned out in 1847. Nearly 100 engines of various classes were built at Greenock up till the year 1856, when the locomotive establishment was transferred to St. Rollox, in the northern district of the city of Glasgow, where the first engine was turned out in July, 1857. Up till midsummer, 1876, there were about seventy engines built at St. Rollox, exclusive of "rebuilds" and "renewals;" and during the past twenty-three years there have been built in the company's workshops no fewer than 161 new engines, many of which, however, being worn out, have been replaced by others supplied by private firms. The total number of locomotive engines built for the Caledonian Railway Company, exclusive of the "rebuilds" and "renewals" just referred to, was, up till 1876, in round numbers, 750, the major portion of which was supplied by the Scotch firms; and the total number at present in use is 689, as against 638 in stock three years ago. The most notable locomotives on the Caledonian Company's system are the well-known passenger engines with 8-ft. driving wheels, the first of which was built in December, 1859, by the late Mr. Benjamin Conner, who succeeded Mr. Sinclair as the company's locomotive superintendent. The present occupant of that important position is Mr. George Brittain, and Mr. Joseph Goodfellow fills the post of manager of the company's principal workshops at St. Rollox. Those works may be said to include about twenty different workshops, and the extent of ground covered by them is about ten acres.

SUMMERLEE IRON WORKS.

Dating back to the year 1836, these extensive works commenced with only two blast furnaces, which were built by the late Mr. John Neilson, of the Oakbank Engine Works, Glasgow, a brother of Mr. James Beaumont Neilson, the inventor of the hot blast, and himself most intimately connected with the early history of the marine engine, and with the use of iron in shipbuilding. They are most conveniently located on a site of some twenty acres of ground, which is bounded by the Monkland Canal, and lies between two of the main lines of the North British and Caledonian Railway systems. The works were rapidly extended to their present dimensions, there being now no fewer than eight blast furnaces, some of which are amongst the largest yet built in Scotland.

The Summerlee Iron Works are invested with a large amount of interest on account of the successful results which have attended the efforts made by the proprietors from time to time to utilise the so-called waste gases of the blast furnaces. Those efforts extend back somewhere about thirty years, but it was not till about a dozen years ago that they resulted in any very decided success. That was by the adoption of what was known as the Addenbrooke system. After Mr. Ferrie demonstrated the possibility of using raw coal in close-topped blast furnaces, the Summerlee Iron Company went a little further, and satisfied themselves that none of the internal structures were requisite, which constituted one of the special features of the Ferrie system. They had adopted the Addenbrooke system, of taking off a portion of the gases to three of their 50-ft. furnaces, and eventually they raised four other furnaces to a height of 70 ft., and closed the tops of the same by the Wrightson bell and cone apparatus. There is also one blast furnace which is still only 42 ft. high, but it is not in blast, and it is probable that it will either be taken down entirely or raised and adapted to the new system of working. Of the 50-ft. furnaces two are in blast, and of the 70-ft. furnaces there are three in blast.

In respect of economy in the use of the close-topped furnaces using raw splint coal, exceedingly successful results have been obtained. The gases taken off are employed in getting up the blast to a temperature ranging from 800 deg. to 900 deg. Fahr., and in raising all the steam power required on the establishment; but even yet there is still a large amount of gas going to loss, and the next effort in economy will doubtless be to turn it to account in some other useful process. There is in the blast furnaces alone a saving of from 8 cwt. to 9 cwt. of coal per ton of pig iron made of No. 1 quality; and as the furnace gas is used in the heating stoves and in getting up steam, &c., there is another saving ranging from 12 cwt. to 13 cwt. of coal per ton of iron. These results are certainly most satisfactory. There are in use two blowing engines that were made at the Oakbank Works, and one that was made by Mr. James Aitken.

The ironstone used at Summerlee is chiefly obtained from various mineral fields in Lanarkshire and Dumbartonshire, to the west of Glasgow, from the Shotts Hills some miles above Airdrie; while the coal is almost entirely got from the Hamilton district and from the neighbourhood of Wishaw. Some Irish limestone is used, but that which is chiefly depended on is got at Levenseat and at the Camps Quarries, near Mid Calder. The annual make of pig iron is from 60,000 tons to 70,000 tons when the works are in full swing, and from 3500 to 4000 workmen are then employed by Messrs. Neilson; at present, however, there are only about 2000 in their service, even including the hands employed in the collieries and ironstone mines.

GOVAN IRON WORKS.

Lying within the present municipal boundaries of Glasgow, in the south-eastern quarter, the Govan Iron Works have, for the last forty years or so, held a prominent position in connexion with the leading industries of the city. The original founder of the business was William Dixon, of Govan, who, as a "collier laddie," left his home in Northumberland in the year 1770, when he was 17 years of age, and settled down in the vicinity of Glasgow. In his early manhood he became the lessee of the Govan coalfield, and ultimately the proprietor of the estate. About the end of the last century he became connected with David Mushet and other partners in the erection of Calder Iron Works, near Coatbridge; and it was just about that time that Mushet made the discovery of the blackband ironstone on the banks of the Calder—a discovery to which we may trace a large share of the influence which Scotland has since acquired in the iron manufacture. Not long afterwards he became the sole proprietor of the works, now consisting of six blast furnaces, and in course of time he acquired so many mineral leases in the neighbourhood of Calder and Coatbridge that he had practically the whole district under his control; indeed, his leases extended over a vast area of ground, and included the lands on which the majority of the present iron works are standing. Whether it was the expiration of the leases or the necessity for an immediate working of the minerals according to terms, certain it is that a few years before the numerous iron works of the district were commenced, lease after lease was given up, and latterly secured by others, until but a very small portion of the minerals, comparatively speaking, was retained for the Calder Iron Works. Early in the third decade of the present century, and shortly before Mr. Dixon's death, the extensive property of Wilsontown or Cleugh, in the Upper Ward of Lanarkshire, passed into the hands of his youngest and eldest sons, John and William Dixon. The Wilsontown Iron Works, including both blast furnaces and malleable iron works, together with extensive coal and ironstone fields, and dating back from the year 1774, were carried on by the Messrs. Dixon (or rather by the eldest brother) for many years; and under the guidance of Mr. Dixon and his well-known manager, the late Mr. John Condie, of steam hammer fame, they were the scene of various important improvements in the manufacture of iron. Active manufacturing operations ceased at the Wilsontown Iron Works altogether in the year 1842.

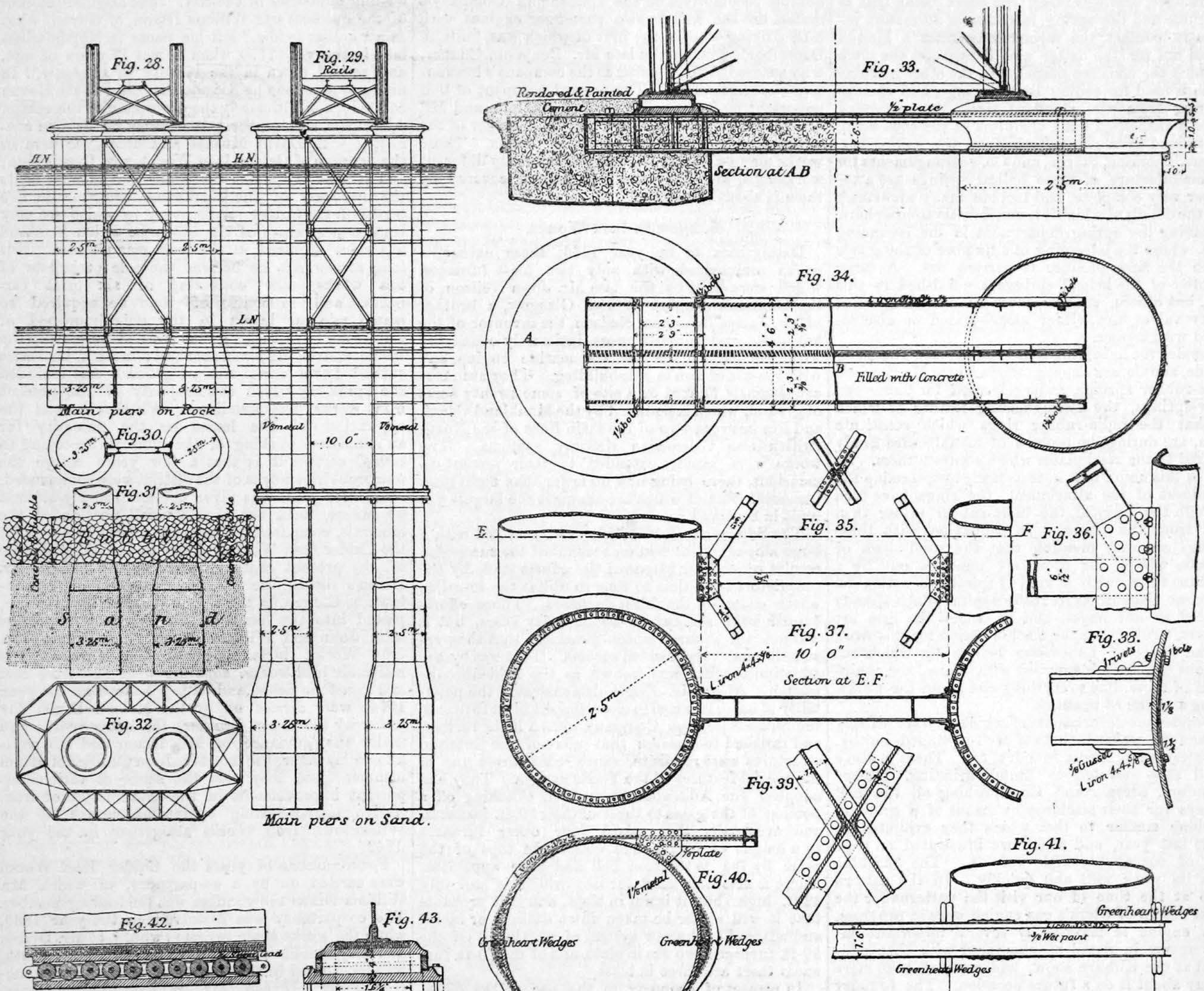
For a number of years the Calder Iron Works were carried on by a co-partnery, of which Mr. William Dixon the younger was the leading member. The co-partnery was dissolved in the year 1835, when the works again reverted wholly to Mr. Dixon, and they remained in his possession till his death, which occurred in the year 1862, when he was succeeded by his son, Mr. William Smith Dixon. Several years ago that gentleman transferred the business to a limited liability company consisting of himself and some six or seven relatives, the title of the company being William Dixon, Limited, and all the extensive collieries, Calder and Govan Iron Works, &c., being carried on as one interest.

The leading feature of the Govan Iron Works as they now stand is a stack of five large blast furnaces. During many years these furnaces were of the same general character as that prevailing throughout Scotland, being low, open topped, and giving a small yield of pig iron. A few years ago, however, the proprietors displayed a strong determination to be abreast of the times in the way of producing pig iron in accordance with the most approved notions as to economy of fuel and labour; and they eventually took the furnaces in hand, one by one, partially or entirely rebuilt them, raised them to a height of 75 ft., and closed them in on the bell-and-cone system, so as to be able to take off the furnace gases for use in heating the blast, getting up steam, &c. The boshes in all cases are 18 ft. in diameter.

Raw splint coal is alone used as the fuel and reducing agent—no coke—and the body of the furnace is in each quite open. The ores used are chiefly blackband and clayband ironstones, together with a mixture of Spanish hematite and forge cinder. The former are chiefly obtained from the company's pits at Carfin, Barbush, Ibrox, and Fauldhouse. We should have mentioned that the coal is got at Blantyre, Carfin, Calder, Wilsontown, and Govan, and that in the year 1876, the company turned out at their various pits about a million and a quarter tons

BRIDGE OVER THE RIVER NILE AT KOHÉ.

MR. JOHN FOWLER, ENGINEER; MESSRS. APPLEBY BROTHERS, GREENWICH, CONTRACTORS.



of coal, a large portion of which, however, was sold in the open market.

A large proportion of the furnace gas is taken off, and used for firing the boilers and hot-air stoves, and there is still a large surplus which has not yet been turned to account. In the reconstructed furnaces, as compared with the old furnaces, there is a clear saving of 12 cwt. of coal per ton of pig iron made; and the produce of the five furnaces is about 1300 tons of pig iron per week, principally No. 1 foundry iron.

There are two blowing engines for driving the five blast furnaces. One of them is a beam engine, which has a steam cylinder 48 in. in diameter and 10 ft. stroke, and two blowing cylinders, one having a 10 ft. stroke and a diameter of 96 in., and the other having a 5 ft. stroke and a diameter of 108 in. This engine has been many years in use. Since the reconstruction and modernising of the furnaces were taken in hand, the blowing power has been materially increased by the erection of a pair of direct-acting coupled engines, having 40 in. steam cylinders and 80 in. blowing cylinders, with 54 in. stroke. Contrary to the usual arrangement of engines of the vertical type, the blowing cylinders are placed on the foundation, and beneath the floor line, the steam cylinders overhead, and the crankshaft and connecting rod between them. By this disposition of the members, the blowing cylinders, together with the strong cast-iron casings with which they are surrounded, serve to a great extent the double purpose of a foundation and air receiver, by reason of their weight and extended surface. The space between the sides of the casing and the cylinder being made sufficiently large to admit a man working freely inside all round, the valves are thus easy of access, and any one can almost immediately be removed and renewed. In general appearance these engines are handsome and compact, and the workmanship is of a very superior and substantial order. They were constructed by Messrs. Dick and Stevenson, Airdrie. The pressure of blast used is 5¼ lb. The hoist is worked by a pair of coupled engines. In the hot-air stoves both pistol and horseshoe cast-iron pipes are used.

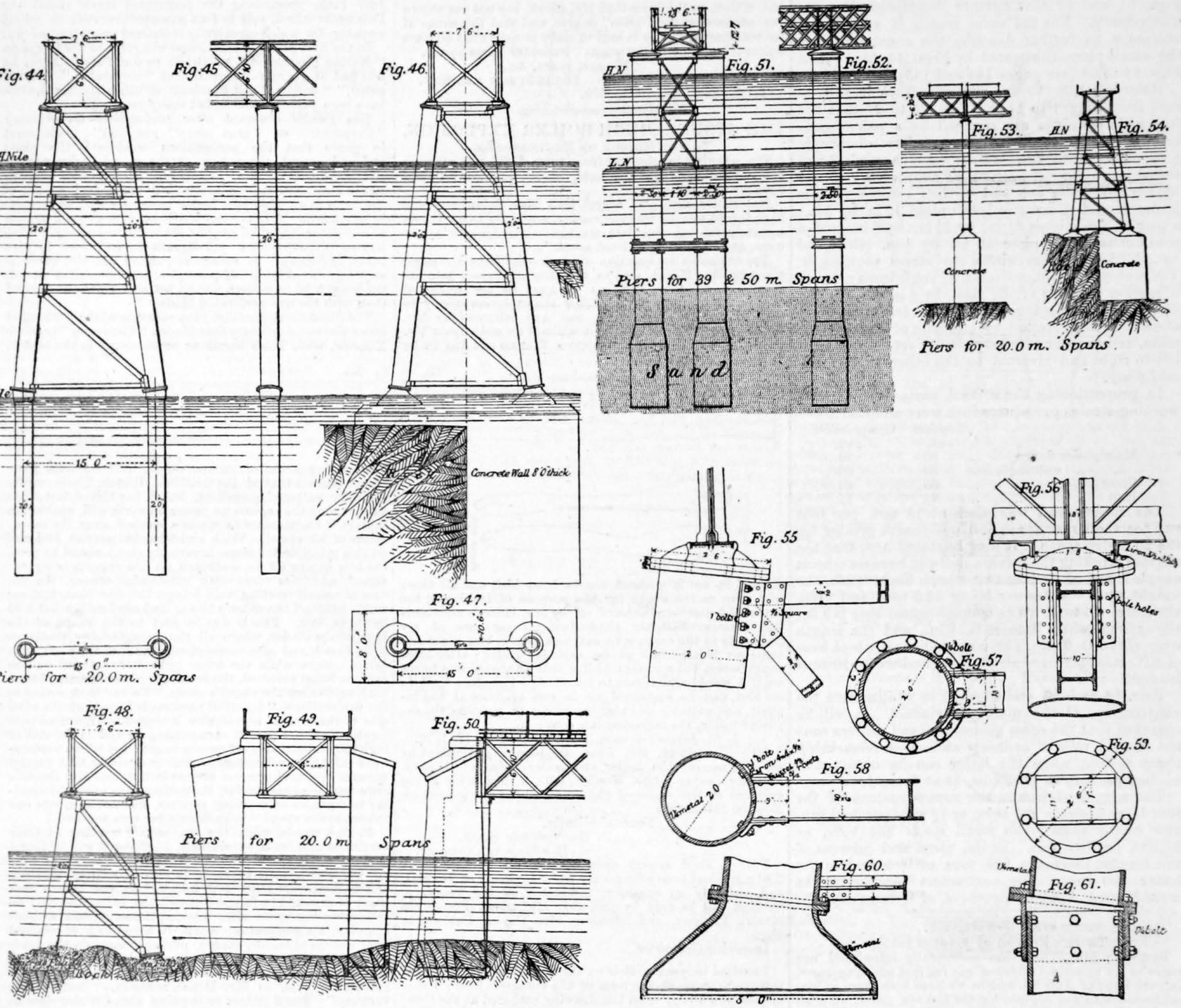
In addition to the blast furnaces there is at Messrs. Dixon's works an extensive forge that has long been famous for its finished iron, including ship and boiler plates, bars, angles, &c. The plant embraces forty-two puddling furnaces, three ball furnaces, three forge trains, three Condie steam hammers, one plate mill, four bar mills—8 in., 10 in., 14 in., and 16 in. trains; and the total produce, when all the furnaces, mills, &c., are in full operation, is about 25,000 tons of finished iron per annum. At present, however, the works are only going about half time. It should be stated that all the puddling and heating furnaces are fired with dross.

There are also extensive fitting shops, foundry, boiler shed, wheel shop, &c.; but in consequence of depression of trade these are at present all standing.

A certain peculiar interest attaches to Govan Iron Works from the fact that the Bessemer process was practically put to the test under the late Mr. William Dixon's auspices some time before it had been demonstrated to be a practical success. An engagement was entered into by Mr. (now Sir) Henry Bessemer and his partner, Mr. Longsdon, that Mr. Dixon should have the sole license for Scotland, that gentleman paying 20,000*l*. down for that right; but as the experiments carried out at Govan Works did not come up to the patentee's expectations, the money was repaid, and Mr. Dixon was absolved from all further responsibility. Some years ago it used to be the practice to show special visitors to the works some of the remains of the Bessemer plant employed in the experiments. Another interesting fact is that the first Siemens furnace brought into use in Scotland was erected at Govan Iron Works. Messrs. Dixon give employment at present to between 5000 and 6000 hands at their different iron works, collieries, &c.

BRIDGE OVER THE RIVER NILE AT KOHÉ.

MR. JOHN FOWLER, ENGINEER; MESSRS. APPLEBY BROTHERS, GREENWICH, CONTRACTORS.



BRIDGE OVER THE NILE AT KOHÉ.

THE Kohé bridge, of which we gave a two-page engraving last week, together with detail views on page 132, and of which we now annex further illustrations, is designed by Mr. John Fowler to carry the Soudan 3 ft. 6 in. gauge railway across the Nile at a point about 1170 miles above Alexandria, and 750 miles below the junction of the White and Blue Nile, at Khartoum. We have already (vol. xv.) fully described the Soudan Railway, so it will suffice to state here that it is a line in course of construction between Wady Halfa, at the second cataract, and Khartoum, the centre of traffic for the equatorial regions of Africa, a distance of about 560 miles by the railway, and 910 miles by the river.

At the point of crossing the Nile takes a rather sharp but regular bend to the right, and the force of the current impinges upon the rocky left bank of the river. The right bank being thus in slack water will not be subject to scour, and the foundations, though in sand, are not required to be of great solidity or of great depth. As a consequence, small and light spans are alone necessary for the greater proportion of the width of the river, and a generally economical structure is obtainable. The singular uniformity in the cross-sectional area of the Nile at different parts of its course is worthy of note. As measured by Mr. Fowler, the High Nile areas at four widely separated points are as follows:

	Miles above Alexandria.	Area, Square Metres.
Barrage	158	7000
Kasr-el-Nil	172	6500
Queremât	214	6850
Kohé	1170	6600

Owing to the fact that the Nile receives no tributary, but that, on the contrary, it is largely tapped throughout its course for irrigation purposes and loses heavily by evaporation and percolation, the flow is much larger at Kohé than at the Barrage. No measurements have been taken at the site of the bridge, but from a comparison of observed flows at other points it is estimated to range from 800 cube metres per second at Low Nile to 14,000 cube metres at High Nile, discharges corresponding to mean velocities of $\frac{7}{8}$ths of a mile and $4\frac{3}{4}$ miles per hour respectively. In ordinary years the flow would not be as much as stated, and as the duration of low water can be calculated almost to a day, and such a thing as a sudden "spate" is perfectly unknown, it will be clear that the difficulties in constructing the Kohé bridge are merely those inseparable from any work situated so far inland and so remote from civilisation. Referring to the general elevation (Fig. 1 of the two-page engraving published by us last week), it will be seen that the bridge comprises 16 spans of 20 metres each supported on cast-iron "limpet" piles filled with concrete and securely based on the rocky bottom of the left half of the river; together with six similar spans resting on screw piles, and a continuous girder bridge having two centre spans of 50 metres each, two side spans of 39 metres, and four piers consisting each of a pair of cylinders braced together and filled with concrete. Facility of erection was of course an essential feature of the design, and with that view the whole of the details were arranged to admit of the construction of the main continuous girder portion upon the side portion of the bridge as a scaffolding, and the erection of the former by rolling forward across the deep current of the river and lowering into place.

The sandy bed of the Nile, except in slack water, is peculiarly liable to scour, hence to secure permanency and to facilitate the sinking of the cylinders a sort of artificial submerged island is formed on the site of each main pier by sinking an open-sided light lattice caisson or crib on to the river bed, filling the space occupied in an ordinary dam by puddle with concrete and rubble, and allowing the central portion to silt up or not as the circumstances may determine. By this means the cylinders are enabled to be accurately set when lowered into place from pontoons in the manner successfully adopted at the Tay bridge, and a permanent protecting collar of concrete and rubble tied together with iron encircles the base of each pier and effectually guards the structure at the only points liable to be endangered by scour. The details of the cylinders, bracing, and crib are so clearly shown by Figs. 28 to 41 and Figs. 51 and 52 that further description is quite unnecessary. For the same reason it will be unnecessary to further describe the construction of the small piers illustrated by Figs. 44 to 50 and Figs. 53 to 61 (see pages 144 and 145).

Referring now to the superstructure it will be seen from Figs. 1 to 14 and Figs. 24 to 27 that the four main openings are spanned by a pair of continuous single-webbed lattice girders of simple construction with deep trusses for cross girders and rolled joists for rail bearers, as shown very clearly by Fig. 26. The top and bottom members of the girder consist of a vertical web plate 12 in. by $\frac{5}{8}$ in., a pair of angle irons $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{5}{8}$ in., and a continuous flange plate 18 in. by $\frac{1}{2}$ in. reinforced by additional plates where the stress requires it. The web consists of one series of angle irons ranging in section from $3\frac{1}{2}$ in. by 3 in. by $\frac{3}{8}$ in. to 5 in. by $3\frac{1}{2}$ in. by $\frac{5}{8}$ in., sloping from right to left at an angle of 45 deg., and rivetted to one side of the vertical plate, and another precisely similar set sloping from left to right and rivetted to the other side of the said plate.

In proportioning the several parts the following working strains per square inch were adopted:

	Tension.	Compression.
	cwt.	cwt.
Main girder flange ...	90	70
,, ,, web angle iron	80	60
Cross girders	80	60
Rail ,, ...	75	75

The rolling load was taken at 18 cwt. per foot run for the larger spans and one-fourth greater for the 20 metre spans. It may be stated here that the engines working the Soudan Railway have six wheels coupled, and a leading two-wheel bogie truck, the weight upon the former being 25.5 tons and upon the latter 4.5 tons. The coupled-wheel base is 9 ft., the extreme wheel base 15 ft. 9 in., and the length over all 26 ft. 9 in. The wagons have a wheel base of 8 ft., a length over all of 16 ft., and weigh 10 tons loaded.

Figs. 12 and 13 and Figs. 15 to 23 illustrate the construction of the small-span viaduct. It will be observed that the cross girders and rail girders consist of steel rails of ordinary section—a remarkably cheap system when the latter can be obtained at 4*l*. 10s. per ton, or even less, as at present.

The weight of iron in the superstructure of the four large spans is 236 tons, or $7\frac{3}{4}$ cwt. per foot run, and in the twenty-two small spans 254 tons, or $3\frac{1}{2}$ cwt. per foot run. In the piers and caissons of the former there are 600 tons of iron and in the latter 200 tons. The contractors for the works were Messrs. Appleby Brothers, of Greenwich.

GAS ENGINES.

To the Editor of Engineering.

Sir,—As Mr. Wilson has incidentally introduced our name in his historical sketch of gas engines which appeared in your issue of July 25, and as we have been more or less connected with gas engines for the last ten years, we shall be glad if you will allow us in your columns to confirm the claim which Mr. Wilson makes for Messrs. Otto and Langen as having brought out the first commercially successful gas engine. It must not however be quite overlooked that that engine, the atmospheric, differed little from one patented in 1857 by two Italians named Barsanti and Mattencci, who may be considered the first pioneers of this new industry. The atmospheric engine was a truly economic one, because gas was only consumed to produce a vacuum, the pressure of the atmosphere doing the real work. In this respect the Otto and Langen, atmospheric, and Gilles' atmospheric (which we in 1877 introduced into this country, having seven years before broken the ground for the Otto and Langen, and successfully battled against the prejudices then existing against gas engines), are superior to the "Otto" and some other direct-acting "high-pressure" engines, but their limited power, and as regards, more especially the Otto and Langen, their unmechanical construction and noisy working, left a wide field for engines not having such disadvantages. Hence the rapid success which attended the "Otto" engine especially while it had the market to itself. Although exceedingly ingenious and effective, this engine can scarcely be said to satisfy all theoretic requirements, for the gas is exploded (we know no other name for the sudden ignition of an inflammable mixture), giving an initial pressure of 155 lb. per square inch. Moreover there is a considerable loss, by absorption in the circulating cold water, of a portion of the heat developed by the explosion. This we have successfully overcome in our "Eclipse" engines by using this heat to generate steam, which, entering into the cylinder, adds to the effective power of our engine, and obviates the effects likely to result from dry gas heat. A further improvement is, that we burn the gas as it enters the cylinder, thus keeping the working pressure down to about 45 lb. on the square inch. It is true that there may be some disadvantage, as Mr. Wilson says, in having two cylinders instead of one, but that is more than compensated for by the even turning resulting from the impact of power at each stroke, a result of great importance for weaving, &c.

It follows from what we have said that we agree with Mr. Wilson in thinking that Mr. Clerk has not yet shown any advance on the "Otto" engine, and that the cause of the economy of gas he is said to claim is somewhat obscure unless it be found in the words "indicated horse power."

We are, yours, &c.,
Louis Simon and Son.

Nottingham, August 9, 1879.

THE STONECLOUGH BOILER EXPLOSION.

To the Editor of Engineering.

Sir,—Owing to absence from town I did not see your publication of August 1st until the 6th inst., or I should have written sooner.

Mr. Hiller says, "I regret that Mr. Baldwin should have forced himself into the inquiry, especially as his report certainly did not elucidate matters, whilst his conclusions were, as you remark, at least novel."

The explosion in question did not arise from the cause given by Mr. Hiller, and as to "forcing myself into the inquiry I will now explain: I went to the works of Messrs. Fletcher on the day after the explosion merely to look at the exploded boiler, and was informed by Mr. Fletcher that I could not see it without an order from Mr. Hiller, as he had sent instructions that no one was to be allowed to see it without a note from him, and all those who were on the works for the purpose of looking at the exploded boiler were ordered off by Mr. Hiller's assistants and Messrs. Fletcher themselves. I sent one of my assistants to the coroner to ask him to give him a note to empower him to look at the exploded boiler; after some conversation the coroner told him that he should like to see me if I would step across to his office; I therefore went to see him, and he requested me to give evidence at the inquest, and gave me an order in writing to examine the exploded boiler, the following is a copy:

5, St. James's-square, Manchester, June 18, 1879.

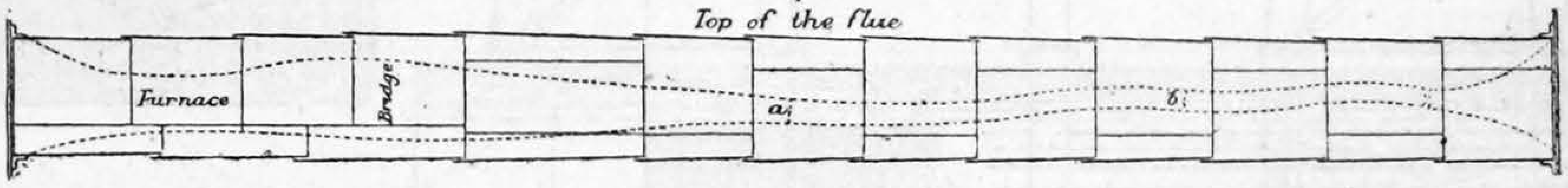
Sir,—The bearer, Mr. Thos. Baldwin, is authorised by me to examine the boiler and boiler-house at Messrs. Fletcher's paper works, Kersley, with a view to his giving evidence of the cause of the explosion at the inquest on Edward Edwardson.

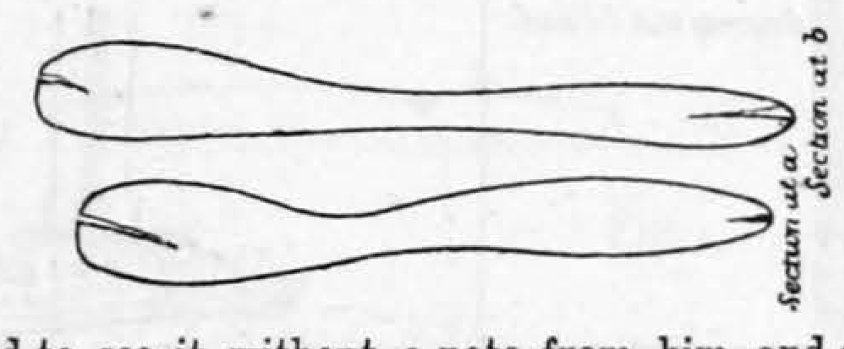
Yours obediently,
J. Broughton Edge,
Her Majesty's Coroner.

P.S.—I shall merely open the inquest to-morrow at 2.30 p.m., and then adjourn for the attendance of counsel, and probably an engineer, instructed by the Treasury. Precept will be sent by post this afternoon. Please see Messrs. Fletcher, and introduce Mr. Thomas Baldwin to them.

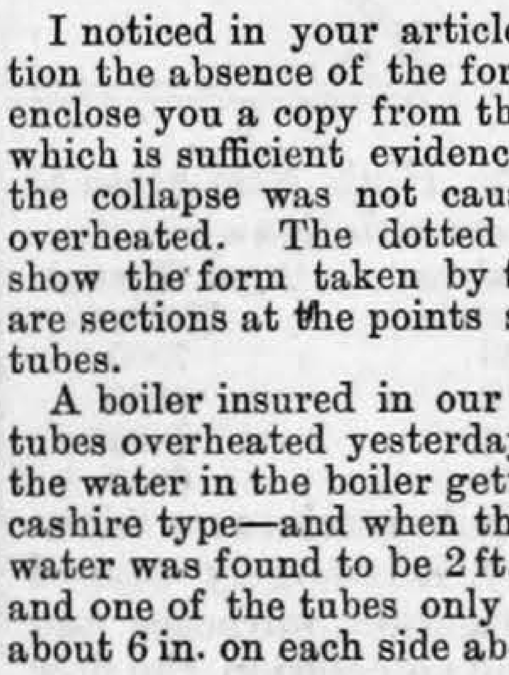
Inspector Grimshaw.

I noticed in your article on the explosion that you mention the absence of the form of the collapsed flues; I now enclose you a copy from the drawing prepared at the time, which is sufficient evidence to convince any engineer that the collapse was not caused by the flue tubes becoming overheated. The dotted lines on the longitudinal view show the form taken by the collapsed flues, and *a* and *b* are sections at the points shown on the sketch of the flue tubes.





A boiler insured in our company had one of its furnace tubes overheated yesterday, Monday, August 11, owing to the water in the boiler getting very low—it is of the Lancashire type—and when the steam had been blown off, the water was found to be 2 ft. 6 in. below the top of the tubes, and one of the tubes only was bulged towards the furnace about 6 in. on each side above the furnace bars, as under, by the dotted lines, at about 5 ft. from the front of the boiler; the other tube is only down at about the same distance from the front, $1\frac{1}{2}$ in. The plates are not rent in any part, only bulged.



It is the object of this company to prevent boiler explosions if we possibly can, but we cannot prevent men neglecting their duty, and allowing the water in the boiler to sink below the furnace tube crowns, which was the case with the boiler just named yesterday morning. It is time that some "novel" views were entertained, and not the constant cry of overheated by the water leaving the boiler in some theoretical way that never existed in practice. There were no such bulges in the furnace plates of the exploded boiler at Stoneclough, as I have shown in the above sketch.

Thomas Baldwin,
Chief Engineer, Mutual Boiler Insurance Company, Limited, Manchester.

SCREW PROPELLERS.

To the Editor of Engineering.

Sir,—Having had no small experience of screw propellers, will you allow me to offer the following remarks on the statements of Mr. H. D. Deane, contained in your issue of July 11th, concerning the perforated screw called the Delamater wheel, said to be a patented invention in actual working, for which superiority is claimed over other screws.

In the first place, if Mr. Deane will refer to the works on "Marine Propulsion," published by our Patent Office, he will find it therein recorded that "perforated," "corrugated," "hollow," and hundreds of other similar devices have been patented and tested many years ago.

The results obtained after perforating an ordinary "Carpenter" or "true screw" propeller" blade went to prove that the perforations weakened the blade and endangered the safety of the vessel under various circumstances. From the result of my own experiments I can conclusively prove that the actual weight of the screw is an important factor in determining the results to be secured. A heavy screw will not give as good results as a lighter screw of exactly the same dimensions. Perforating a heavy screw will lighten it, and tend to give better results and to reduce vibration; but the screw is seriously weakened. If strengthened by adding metal, the weight is increased, and no better results are secured than with the non-perforated blade.

The illustration given in your columns of the perforated screw shows an ordinary four-bladed "Carpenter" or letter X screw, with holes bored or countersunk in the blades. The backing power of such a screw, with its wide periphery, exceeds that of the Griffiths, Hirsch, Thornycroft, and other patented propellers, but it has this defect, that on reversing the engines no power on earth will enable the captain of the steamer to retain a control over the movements of his vessel. With right-handed screws designed on this principle the stern invariably slews round to port, the bow paying off to starboard on the engines being reversed, and *vice versâ* with left-handed screws. In the case of vessels meeting, this brings the one that first reverses athwart the other's bows, and renders her liable to be cut in two. This is due in part to the shape of the back of the blades, where all the strengthening matter is to be found, and here, consequently, part of the blade only drives astern while the other part drives ahead on the engines being reversed, the resultant of the opposing forces tending to slew the vessel's stern. To say that, owing to the perforations, "a partial vacuum is formed on the after side of the blades" is evidently incorrect. Where no perforations exist, a partial vacuum may be and is formed at high speeds by nearly all screws in use; but where perforations exist they will naturally tend to diminish that partial vacuum by allowing water to pass into it, and Mr. Deane's argument is at once upset, the perforations evidently tending to diminish an existing vacuum and not to create one to enable the vessel "to back into her own suction."

At high speeds, when the engines are working at their maximum number of revolutions, I believe it will be found that no water passes through the perforations, but that the water previously taken in is carried round. If these perforations were filled with tallow, I do not believe that much of it would be forced through the holes, and that on examining the screw after working it some hours without stopping, the perforations would be found to have retained their charge of tallow, except, perhaps, towards the leading corner of the blade, where we might fined "jets or columns of water forced through these holes in vortex motion." This, as Mr. Deane remarks, "destroys the vacuum." But if it does so in going ahead it also does so in going astern. Here Mr. Deane contradicts himself.

As to the corrosion which sets in on the backs of the ordinary screw propellers in use, in rear of the leading corner of the blade, it appears to me to be entirely due to the fact that these screws lose their grip upon the water as soon as the speed of the engines exceeds a given number of revolutions, the blades of the screw then cutting out a hollow shell, or creating a vacuum behind them by throwing up the water displaced by lateral action to form the stern wave common to all modern screw steamers. This stern wave or dome overhangs the hollow in which the screw now works, and the weight of the superposed water breaking down and into the hollow, causes the screw to work in broken water, while at the same time the back of each descending blade receives the weight of the water falling through the vacuum it leaves behind it. And just as a continued drip of water will perforate a stone, so the drip in this case perforates that part of the blade where the vacuum exists. The only remedy for this defect is to so form your blade in each case as to prevent its forming a vacuum at the maximum speed at which it is designed to run.

It appears to me that the screws that have been replaced by the perforated propellers must have exceeded it in weight, while any slight alteration of pitch, when correctly computed, would not fail to improve the performance of the lighter screw.

I have no objection whatever to test this matter with Mr. Deane. The steam yacht Dida, of 83 tons, working up to 65 horse power, is fitted with a cycloidal screw 5 ft. in diameter, and has been kindly lent by Lord Alfred Paget to the patentees of this invention for experimental purposes in the development of their patent. As the inventor of the cycloidal principle on which to design screw propellers, I shall be happy to let Mr. Deane perforate the Dida's screw on the sole condition that, should no better results be obtained than with the screw unperforated, he shall replace it at his own cost.

I must state, however, that there is absolutely no vibration at present, although the cycloidal screw in use is only two-bladed, and that, with this screw, the Dida answers her helm as well when going astern as when going ahead, facts which can be verified by any gentlemen who desire to do so.

I may claim that the "cycloidal screw" is not waiting to be tried to prove what are its advantages over other screws, and it is already being worked by nearly 3000 horse power distributed in vessels ranging from 900 to 50 tons.

I am, Sir, yours truly,
ROBT. H. ARMIT,
Lieutenant R.N.

13, Clifford's Inn, July 14, 1879.

THE PERKINS SYSTEM.

TO THE EDITOR OF ENGINEERING.

SIR,—As I leave in a day or two for South America, I wish to explain the delays in giving further information of the Wanderer's machinery have arisen solely from unexpected difficulties with the ordinary low-pressure slide valve; the specialties of the system give no trouble, and there is evidently a bright future for this safe system of high pressure.

It is quite useless to place before your readers incomplete results, and until the fault I have named is remedied no accurate results can be obtained. Mr. Perkins will no doubt complete the plans I had nearly prepared for you, and also give you the results of the further trials.

It seems absurd to raise arguments on facts that have not even appeared on paper. The *Field* never stated that 12 or 13 miles required 800 indicated horse power. The Wanderer requires about 550 horse power for 11 knots, and it is well known that the friction of the Perkins piston and valves is less than ordinary compound engines.

Mr. Perkins has no reason to shrink from honest criticism like that of Mr. Flannery. I fear in the case of Mr. Bury's *friendly* criticism Mr. Perkins must say, "Save me from my friends."

I am, Sir, your obediently,
London, August 13, 1879. J. F. SPENCER.

A NEW STEAM ENGINE INDICATOR.

TO THE EDITOR OF ENGINEERING.

SIR,—Having had considerable experience in the manufacture and use of the "Richards Indicator," I would like to say a few words concerning it, suggested by reading the account of the new indicator by Mr. Sweet on page 117 of your number of August 8th.

I am quite aware of the importance of making the moving parts as light as possible, and some time ago suggested what I thought an improvement by taking away exactly half the parallel motion, and making the pencil work in a slotted guide—the result was as I expected, the diagram was free from undulation; but if any one expects to obtain diagrams free from undulations by simply reducing the weight of the parallel motion they will be disappointed; if the parallel motion is removed altogether, and there is no weight on the piston rod at all it will vibrate just the same. I have taken diagrams perfectly free from undulation by simply using plenty of clean tallow on the piston, and taken them before the indicator has got very hot, the present construction allows this to a certain extent. Another way is to apply more pressure to the pencil and so produce friction. This need not cause any error, and will frequently get rid of vibrations, but I have no hesitation in saying if it were possible to use the indicator cold and lubricate the piston with clean tallow, there would be no necessity for trying any other parallel motion than the present one.

In taking diagrams from launch engines working up to 400 or 500 per minute, it is necessary to use a spring so strong that a weight of 50 lb. will only compress it about ¼ in.; what effect will the weight of the parallel motion have in this case? I do not think that ½ oz. falling on to a spring under this tension would produce the slightest result, and yet it is difficult to obtain diagrams free from vibration; it is not in the parallel motion but in the spring, and this can be checked in the way stated above.

I am, Sir, yours, &c.
J. RICHARDSON.

COMPRESSING FLUID STEEL.

TO THE EDITOR OF ENGINEERING.

SIR,—The expulsion of gases from fluid steel under the process of compression, which forms the subject of Mr. Ellison's letter in your issue of the 8th inst., was fully discussed at the Manchester meeting of the Institute of Mechanical Engineers (see Proceedings, July 1875) in connexion with Sir Joseph Whitworth's paper "On Fluid Compressed Steel and Guns," and various theories were brought forward to account for a result which was generally admitted, although not very satisfactorily proved. In the case of the system of compression practised at the Edgar Thomson Steel Works, U.S.A., fully illustrated in your number of the 1st inst., the fact of the expulsion of the gases is, I think, clearly demonstrated by the loud roar and blue flame which issues from the bottom of the mould. I have myself seen this process in operation at Pittsburgh, and can testify to the fact.

At the forthcoming meeting of the Iron and Steel Institute to be held at Liverpool, I propose to read a paper on this subject, and as the system is now in operation at the works of Messrs. Bolckow, Vaughan, and Co., I hope to be able to bring forward additional information both in regard to the cause and effect of this method of compression.

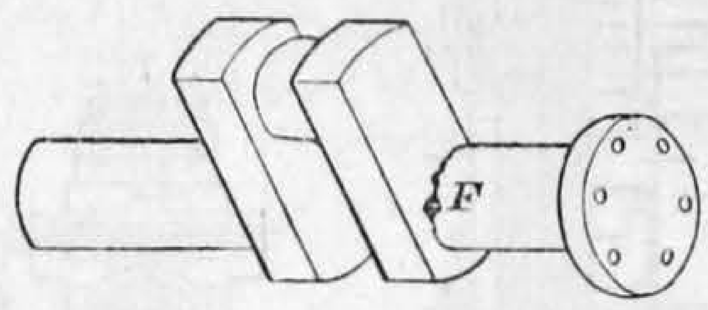
I am, Sir, yours truly,
ALFRED DAVIS.

5, Westminster Chambers, Westminster, Aug. 19, 1879.

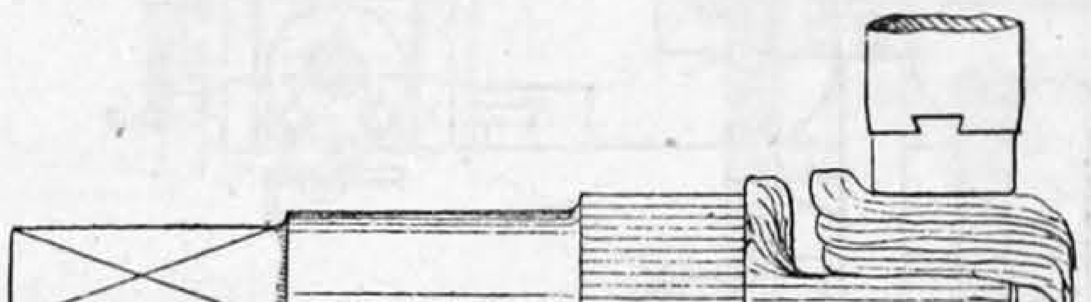
THE FORGING OF CRANKSHAFTS.

TO THE EDITOR OF ENGINEERING.

SIR,—I am exceedingly gratified at the careful and correct manner in which my paper appears in your impression of Saturday; the only thing being that in No. 6 of the diagrams the flaw F is rather indistinct; of such with such a small scale it would require to be somewhat exaggerated to be seen; a hole had been bored in the rupture to see how far it extended, thus:



I am also pleased at the generally correct report of the discussion, but had I been aware that you also reported subsidiary diagrams, I would have resorted to the black board to have explained more fully to Mr. Williams the point he adverted to, of the slabs being always made 6 in. shorter than the piece they were being welded to, which explanation satisfied him, and which point is one of the nicest parts of the whole arrangement. Had I been theorising I would probably have drawn the slabs full length, but I would likely have had down upon me at once some practical forgeman, who might have said, "Hilloa! there is something wrong here, you will have a great waste of iron quite needlessly." And he would have been perfectly right, as has been proven over again in the working, and which I will clearly explain. Suppose they were made all the length, they being much thinner than the body of the mass they were being welded to, must needs draw under the hammer to a greater extent, and the consequence would be that the first two or three bats of the hammer would sent part of the iron over the edge of the piece, hanging down like dog's ears, or like the pitch from a pitch-covered roof on a very hot day, somewhat like this:



It cannot be otherwise, for the iron has nothing to weld upon, and must either be cut off by the forgeman as waste, or he will allow it to be dissipated in the furnace. Each 4 ft. long slab would be about 8 cwt., and 6 in. of each would be 3 cwt. on the 24 cwt., or 12½ per cent. of waste on each lay of iron. After being at the trouble and expense of getting up so carefully prepared slabs to have them subjected to such waste for no practical advantage at all, would, indeed, be very discreditable to any one's management, and would increase the cost very much. I was exceedingly surprised when I heard one of the speakers say not only that he made his shafts in the way I indicated, but used the slabs all the length of the width of the crank. If so, I am very certain he will soon discontinue it, for it must be borne in mind that it is the mass to shape the crank out of that is being made, not the crank itself, *per se*, and the cropping cut off either gable, as shown at Fig. 19, on page 137 of your last number, is what is convenient for another lay, and which is cut off the gable whether made by first, second, or improved method; not the mere surplus of each layer of slabs, which fag ends being in small pieces, can only be cut up at the shears again, and piled as scrap iron. I invited all interested to call at the forge here, and witness the process for themselves. Numbers of the members favoured me by calling, and closely inspected several large crankshafts in various stages of progress, saw for themselves the perfect welding of the gables, and the complete shaft when made; and all expressed their thorough appreciation and approval of the method. I may repeat, what I mentioned at the meeting, that in bringing forward my paper I desired to create no monopoly of the manufacture for myself, but during the present depression of trade, and consequent keen competition on every side, all means are taken to cheapen production, the results being that few newspapers are taken up without some casualty being observed reported, and it is no wonder that shipowners are at their wit's end to get reliable crankshafts, and in despair are turning their attention to steel even at a greater cost, in the hope of averting the breakages so frequently occurring. If the plan I have advocated is generally adopted, it will no doubt give greater confidence in the future, as engineers still prefer to specify scrap iron for such shafts. Should this be effected, my object in bringing forward my paper will be achieved, for it will be in the power of all engineers thus to examine the process for themselves, and see that it is carried out in its integrity, both as regards method and material.

I am, &c.,
W. L. E. MCLEAN.

Lancefield Forge, Glasgow, August 18, 1879.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—A further advance in the price of warrants took place last Thursday, partly in consequence of expected difficulties between the mineowners and their workmen, owing to a general determination on the part of the latter to restrict the "darg" or day's work. An impetus was also given to it from the fact of two large shipments of 1000 tons of old rails to New York. Quotations started at 42s. 6d. cash—an advance of 3½d.—and mounted up to 43s. cash, while a fortnight previously 40s. 5d. was accepted. There was a weakness in the afternoon, and prices receded to 42s. 10½d. and 42s. 9d. cash and to 43s. 1d. and 42s. 10d. one month, closing sellers at the latter figure, or 6d. over the closing price of the previous day, and buyers at 42s. 8d. cash and 42s. 9½d. one month. The warrant market was again strong on Friday, and a further advance of 6d. per ton was obtained, making an advance of 1s. 4d. on the week. Business was done during the forenoon at from 43s. 3½d. to 43s. 1d. cash, closing with sellers at the latter sum, and buyers offering 1d. per ton less. During the afternoon quotations ranged from 43s. 1½d. to 43s. 3d. cash, and the market closed with buyers offering 43s. 3d. cash, and 43s. 4½d. one month, with sellers asking 1½d. more. Monday's market was very strong at the opening, sellers seeking a further advance of 9d. per ton, a small portion of which, however, was dropped at the close. There were transactions during the forenoon at 44s. down to 43s. 9d. cash, and at 44s. 1½d. to 43s. 10d. one month, buyers over at the close at the lower prices, and sellers asking 1d. per ton more. The afternoon quotations were 43s. 10d. cash and 44s. one month, sellers closing at those prices, and buyers offering 43s. 9d. and 43s. 11d. cash, and one month respectively. Business was done yesterday forenoon at 43s. 10d. to 44s.o and down to 43s. 9d. one month, also at 43s. 8d. tt 43s. 10d., and again down to 43s. 7½d. cash, the markee closing with sellers at 43s. 7½d. cash and 43s. 9d. on month, buyers 1½d. less. Iron changed hands in the afternoon at 43s. 6d. and 43s. 4½d. cash, also at 43s. 7d. and 43s. 6d. one month; and at the close there were buyers at 43s. 4½d. cash and 43s. 6d. one month, and sellers at 1½d. per ton more. The market was flat this forenoon, when business was done at 43s. 7d. down to 43s. 2d. cash, also at 43s. 7d. down to 43s. 4d. one month, sellers at the close asking 43s. 4d. cash and 43s. 6d. one month, and buyers offering 1d. less per ton. Flatness was again the rule in the afternoon, sellers at 43s. 1½d., and buyers at 43s. cash. Prices having advanced to the extent of 2s. 7d. per ton during last week and the preceding week, the market seems now to have taken a stand for a time, but it can scarcely be expected to remain where it is. The suddenness and unexpected extent of the rise have been somewhat severely felt by several iron brokers who had entered into arrangements for supply at lower figures than they can now purchase at; and one broker has actually had to intimate his inability to fulfil his engagements. Should the improvement now being reported from America be maintained, it will soon make itself felt on all hands; in the meantime, however, no change of any importance can be reported in the home trade. Makers' quotations are now advanced 1s. per ton all round. Last week's shipments of pig iron from all Scotch ports amounted to 8652 tons, as compared with 6162 tons in the corresponding week of last year. One blast furnace having been blown out at Ardeer Iron Works, there are now 89 furnaces in actual operation as against 96 at the same time last year. Iron still continues to be sent into the public warrant stores, and the total stock with Messrs. Connal and Co. up till last Friday night was 292,361 tons, showing an increase on the week of 2038 tons.

Port-Seton Harbour.—This extensive work, which is in course of construction at the instance of the fishermen of Cockenzie, is rapidly nearing completion, a large staff of workmen having been employed, since its commencement in December last year, by the contractors, A. Morrison and Son, Edinburgh. Already 200 yards of sea wall have been formed, and 60 yards of the inner or quay wall, and at every distance of 30 ft. strong cross walls have been erected. The slope of the sea wall is 2 in. per foot, while that of the inner wall is 1½ in. per foot, and the quay, with an inclination of 1 in 50, is being covered with concrete 10 in. in thickness. An iron cope is carried along the harbour wall with bollards placed at convenient distances. It is also intended to erect a parapet along the sea wall, rising by stages to 9½ ft. at the west end, and a line of steel rails will be placed the whole length of the quay. The height of the quay wall is 21 ft. 6 in., thus allowing 5 ft. above that of ordinary spring tides, which reach 16½ ft. Mr. Jas. Norrie, the local manager, hopes to bring the whole undertaking well nigh to a close at the end of the present year.

Hydepark Locomotive Works—A Correction.—A mistake occurred in the notice which appeared in last week's paper regarding Hydepark Locomotive Works, which it would be well to correct at once. When Mr. Reid became the managing partner of the works at the end of 1863 the firm had made about 1000 engines of all sorts—land, marine, and locomotive—and not in the year 1858, as stated in the notice referred to.

Rapid Steaming.—The Allan royal mail steamer Sardinian, which arrived at Liverpool on Sunday evening, is reported to have made the "fastest passage on record" between Quebec and Liverpool, the actual time occupied in the run from port to port having been eight days, seven hours, and thirty minutes. The two previous voyages of the same steamer were also accomplished with remarkable celerity, and until this last performance of the vessel it was claimed for them that they were the quickest on record.

The Aberdeen Harbour Bills Contest.—It is stated that the expenses incurred by the elected Harbour Commissioners of Aberdeen in connexion with the recent Parliamentary contest amounted to 2000*l.*, which, along with the expenses falling on the Town Council and Harbour Board, makes the total cost of the contest close on 6000*l.*, whereas the Bill might have been passed at perhaps not more than 700*l.* if it had been uncontested.

WATER SUPPLY OF BRISBANE.—The Colonial Treasurer of Queensland has instructed Mr. Henderson of the Harbour and Rivers Department, to report upon the present water supply of Brisbane, and the best means of extending its The Municipal Council has also adopted plans for the drainage of the city.

DOUBLE LATHE FOR DISC RAILWAY WHEELS.

CONSTRUCTED BY MESSRS. A. FETU AND DELIÉGE, ENGINEERS, LIÉGE, BELGIUM.

Fig. 1.

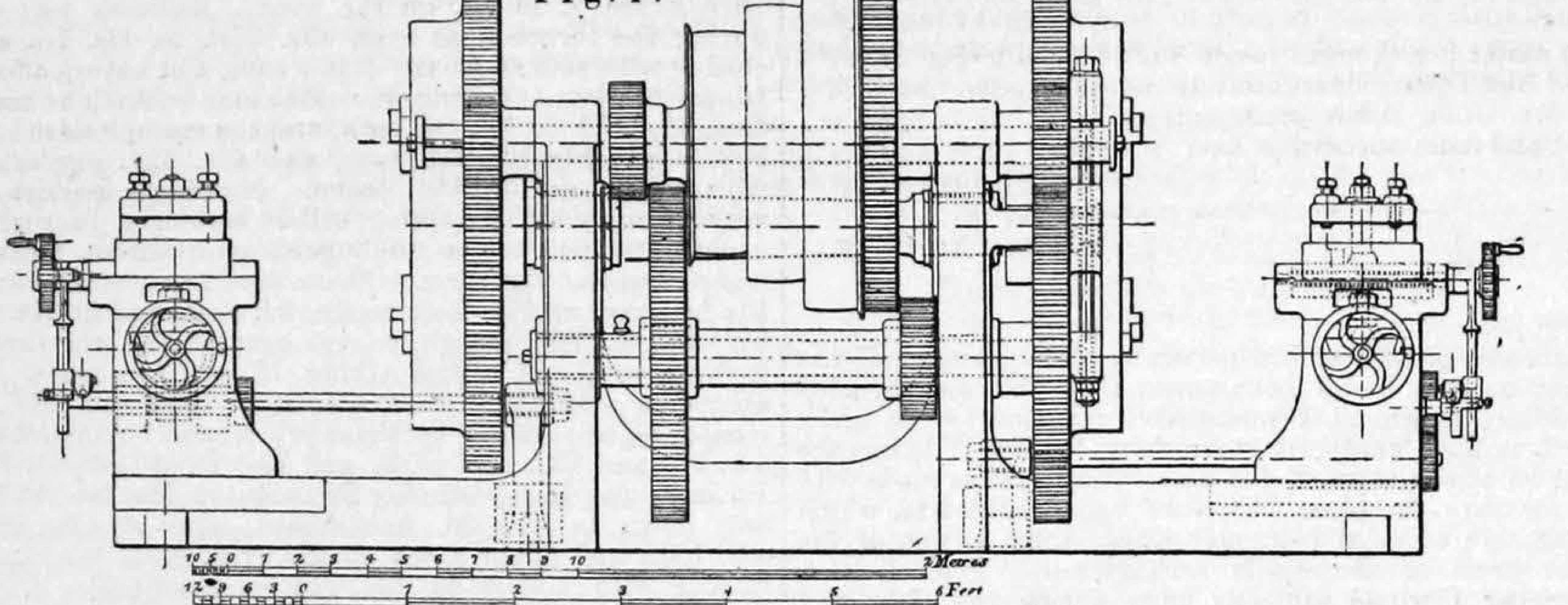


Fig. 2.

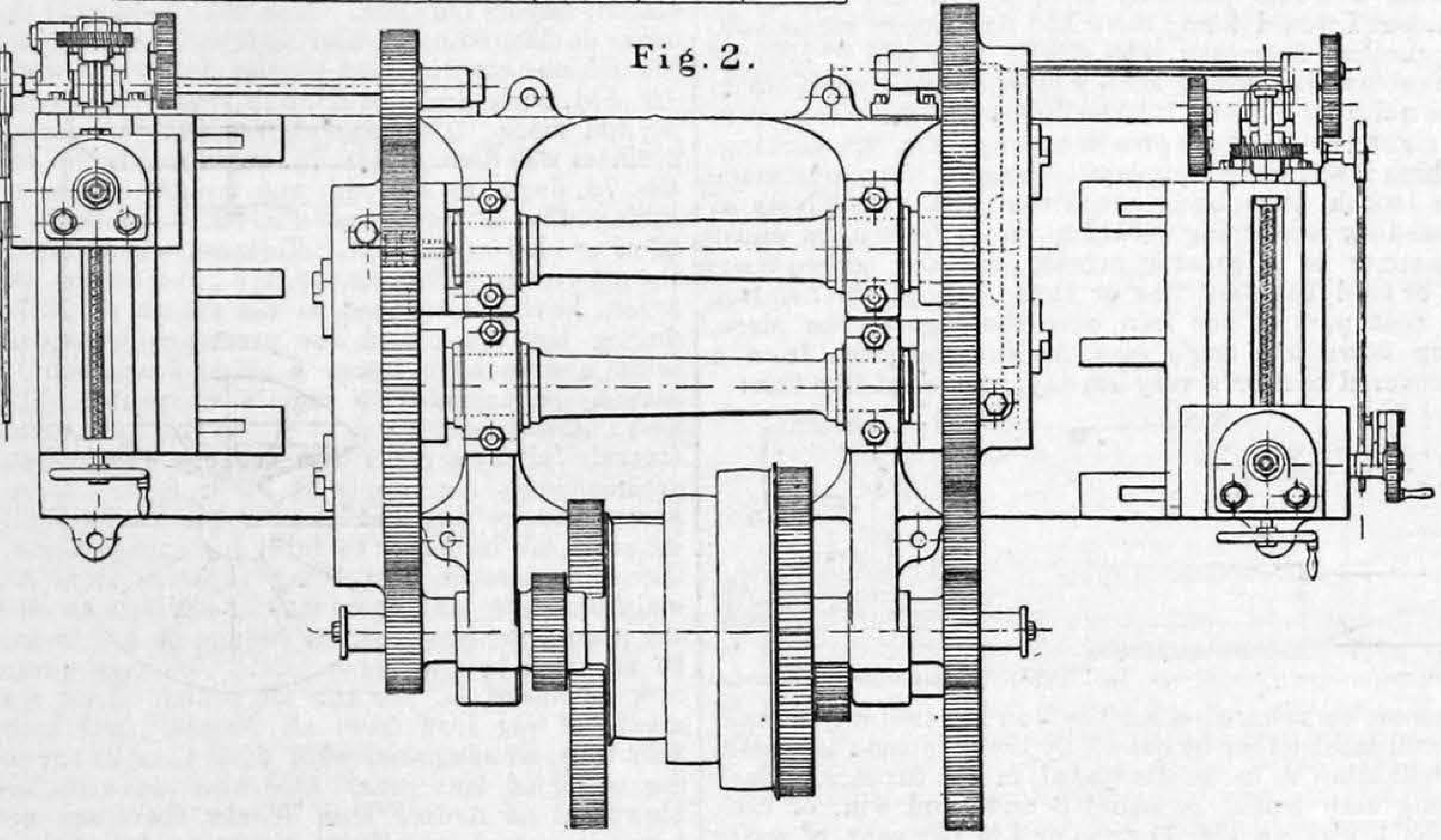
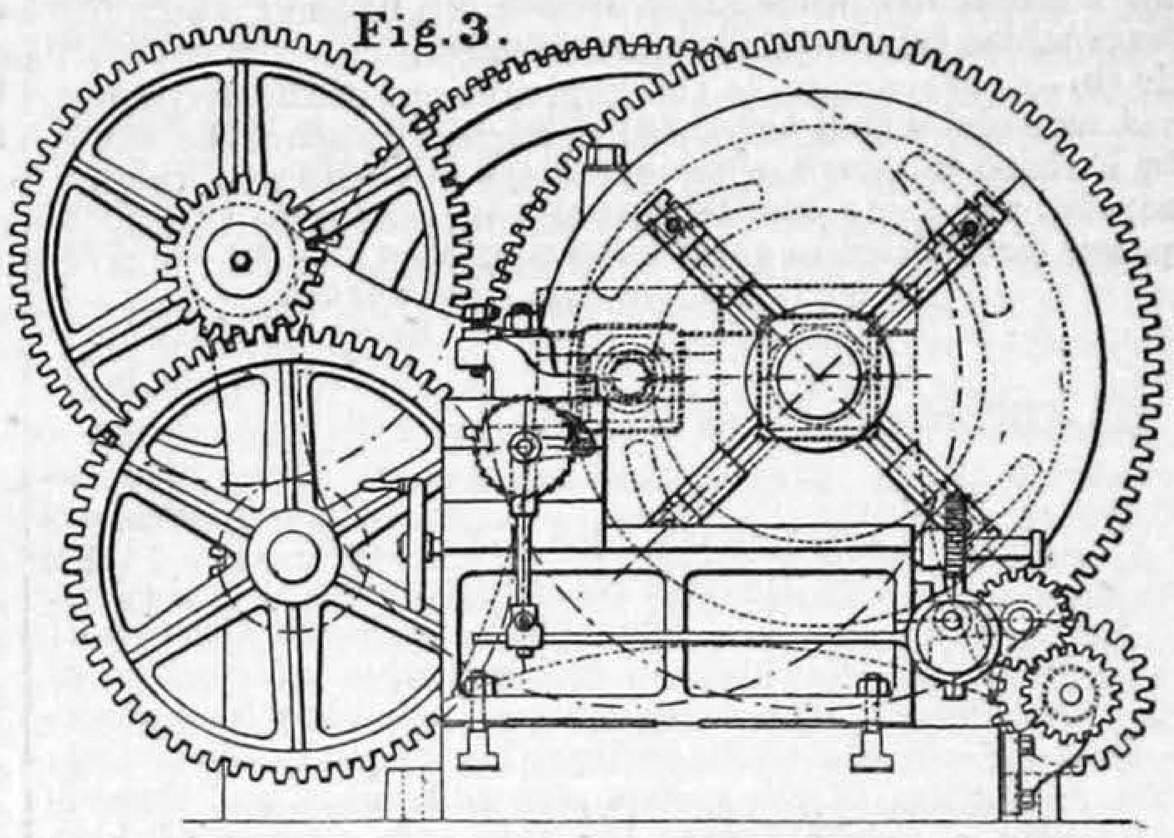


Fig. 3.



WE annex engravings of a double lathe especially designed for turning and boring cast steel disc wheels for railway carriages, this lathe being one constructed by Messrs. A. Fetu and Deliége, of Liége. As will be seen from our engraving the machine consists of a substantial bedplate having a headstock cast in one with it. This headstock carries two parallel spindles, each provided with its faceplate, but these faceplates being at opposite ends as shown. The driving gear consists of a single set of cone pulleys furnished with back gear as shown, the spindle carrying the cone pulleys giving motion to both faceplates. The faceplates are both toothed in their peripheries, and the one—that on the left in Figs. 1 and 2—gears directly with a pinion on the cone pulley spindle. In the case of the other faceplate, however, an intermediate wheel is provided between the faceplate and the pinion on the cone-pulley spindle, this idle wheel being necessary to give the faceplate motion in the required direction. The arrangement of the gear is shown in end elevation in Fig. 3, from which and the other views the details will be readily understood. It will be noticed that by shifting the pinions on the cone-pulley spindle either one of them can be thrown out of gear with the wheel which it drives, thus enabling one half of the machine to be worked without the other. Each faceplate is furnished with a slide rest mounted as shown, the tools having a self-acting traverse in both directions.

DAMAGED AGRICULTURAL ENGINES AND MACHINERY.

THE secretary of the Royal Agricultural Society has just issued the subjoined circular. The object which the Royal Agricultural Society have in view in collecting the examples of the careless usage of engines and machines referred to in the circular is an excellent one, and deserves every support. Such a collection of exhibits as it is proposed to get together is calculated to do much service. The circular is as follows:

Sir,—I am instructed by the Council of the Royal Agricultural Society of England to invite you to send for exhibition at Carlisle next July, any instructive examples or specimens of agricultural engines and machines, and parts thereof, damaged through the negligence of the men in charge, which may have come under your notice. Any information, also, which you may be able to furnish in reference to the circumstances under which the damage was done in each case, will be most desirable. These specimens will be exhibited in a special shed in the showyard at Carlisle, for the purpose of illustrating the damage which may be produced by careless or uninstructed persons; the great loss caused, particularly the danger to human life; and also to indicate the direction in which improvements may be made in the management of such machinery.

I shall be glad to know not later than March 31 whether you propose to send any specimens of damaged machinery for exhibition, and in the event of your electing to do so, I shall be obliged by your supplying me with a list. It will be necessary to forward the specimens so that they may reach Carlisle not later than the 15th of June next year.

I remain, yours very faithfully,

H. M. JENKINS, Secretary,

ASSOCIATON OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.—The ballot for the President of this Association for the ensuing year just completed, has finally resulted in the election of Mr. Edward Pritchard, C.E., F.G.S., of Great George-street, Westminster, and Warwick. The votes of all members of the Association are taken by ballot papers, and the first return, singular to relate, resulted in a tie between Mr. Pritchard and Mr. Deacon, the borough engineer of Liverpool.

PROTECTION OF ROYAL PALACES FROM FIRE.—Her Majesty's Commissioners of Works have determined upon a most complete fire service for the protection of Hampton Court Palace, and have entrusted the carrying out of the work to Messrs. Merryweather and Sons, who have already supplied similar machinery for Osborne, Sandringham, Marlborough House, and other royal palaces. The appliances at Hampton Court will include one of Messrs. Merryweather's patent steam fire engines with double cylinders, similar to those which secured two gold medals at the Paris Exhibition, and having a capacity equal to throwing four or more powerful jets simultaneously.

SANITARY CONGRESS FOR 1879.—The Sanitary Congress and Exhibition of the Sanitary Institute of Great Britain will this year be held at Croydon from October 21st to November 8th inclusively. Dr. Richardson, F.R.S., has accepted the office of President of the Congress, and a large and influential committee, Mr. John Corry being the chairman, has been formed. Amongst the vice-presidents are the Archbishop of Canterbury, Earl Percy, the Earl of Egmont, the Bishop of Rochester, Mr. George Cubitt, M.P., Mr. Alexander M'Arthur, M.P., Mr. W. Grantham, Q.C., M.P., Sir Trevor Lawrence, Bart., M.P., Mr. J. Watney, &c. The Sanitary Congress is divided into three sections as follows: Section I. Sanitary Science and Preventive Medicine, President, Mr. Alfred Carpenter, M.D., Lond. I.P.—Section II. Engineering and Sanitary Construction, President, Captain Douglas Galton, R.E., C.B., F.R.S.—Section III. Meteorology and Geology, President, Mr. G. J. Symons, F.R.S. Arrangements have also been made for one or more lectures, one of which will be delivered by Professor Corfield, M.A., M.D.

RUBBER-TYRED TRACTION ENGINES.

*On the Working of Traction Engines in India.**

By MR. R. E. B. CROMPTON, of London.

(*Concluded from page 107.*)

Working Cost.—Table II. (page 150) gives an analysis of the working expenses for the first four months of two years, 1873 and 1874, during which periods the running was most regular. For 1873 the figures for working expenses are furnished by the report of the committee before referred to. For 1874 they have been worked out directly from copies of the train diaries, which after the sitting of the above committee were kept in full detail. It will be seen that the working expenses per train and ton-mile were slightly reduced during the latter period. The economy shown would have been greater had not the pay of the European portion of the staff been raised for the later period, thereby increasing the item for wages and general charges. It must be borne in mind that the trains were only loaded one way, because at one time of the year the traffic set in one direction, and at another time in the opposite; therefore the proportion of empty trains and dead weights hauled is very great compared to the paying load on which the mile-tonnage is calculated. Following the items in order the charge of 10.2d. per train-mile for fuel is about double what it would have been in England, if coal at 15s. 6d. a ton had been obtainable. The next three items, viz., repairs to engines, repairs to rolling stock, and wages, are undoubtedly light, owing to the cheap price of labour. The last item of general charges, viz., 5.85d. per train-mile for superintendence, raising water, office expenses, &c., is high, a very large proportion of the salaries of the superior officers of the establishment being charged in this item. When once the train had passed its experimental stage, these charges would have been divided over a much larger number of engines and consequent mileage. As to the important point of repairs, the engine repairs proper—*i.e.*, the general renewal of all wearing parts, the tightening up and replacing of all portions of the framework, wheels, springs, &c., which fail from the constant vibration—were much lightened at the expense of the rubber tyres. The writer thinks he has fair grounds for believing that these ordinary repairs and renewals were not so heavy and expensive as those of metre-gauge engines used on the Northern State Railway. He takes these engines as a standard of comparison because this railway was originally laid down on the surface of the Grand Trunk road, and the conditions as to dust and mud were therefore very similar to those of the train now described.

In excessively favourable weather—soon after the cessation of the rains and before the coating of dust ground up from the surface of the metal had become considerable—the engines often made several trips of 56 miles each without any of the brasses requiring adjustment. But later on, when the layer of dust was often 2 in. thick, and often a following wind blew the whole dust of a train having sixty broad wheels right over the engine, it was impossible to run a single half trip of 28 miles without carefully readjusting, fitting together, and scraping to a bearing, all the principal brasses in the motion proper. Eventually native workmen were taught to do this efficiently and thoroughly; and by the adoption of white metal linings for many of the wearing surfaces (which could be easily replaced at the half-way repairing shops), the cost of these adjustments of the wearing parts was considerably reduced; but throughout it remained a heavy item, and one which engineers unacquainted with Indian dust would think excessive.

The renewals of broken crankshafts and countershafts form a large item of the engine repairs. Mr. Thomson always considered that the polished wheel treads of his wheels would slip sufficiently within the rubber tyres to relieve the shafts of strain when the engine ran round slight curves; but although the strength of these shafts was increased until they became disproportionately ponderous, their failure was only a question of time. They failed quite slowly—small flaws gradually enlarged themselves until the shaft gave way, generally in a crank journal, sometimes in the centre of the crank cheek. Latterly orders were given to the drivers to run always in slow gear, *i.e.*, always transmitting the power through the countershaft, and thus putting the whole torsional

* Paper read at the Glasgow Meeting of the Institution of Mechanical Engineers.

strain on this, which was a straight iron shaft. The ratio of gearing was altered so that the piston speed did not need to be unnecessarily increased. This got over the difficulty in a measure; as although the countershafts always eventually failed, they were straight lengths cut off the round bar and were cheap to replace.

In direct proportion to the improvement of the driving-wheel armour, which prevented in a great measure the slip of the wheels within the tyres, did the difficulty with these shafts increase. It was the writer's intention to fit to the countershafts the differential gear commonly used on traction engines, but the cost of this was not sanctioned until the writer had left India.

Muirhead, his successor, show that on the tyres C and E, H and I, most of the wear was due to first few months' running; later on increased care in management, and improvement in the protecting armour, greatly reduced the wear, and on all these four sets of tyres it became extremely small.

The writer has thought it not out of place to put at the foot of the Table some carefully noted results obtained from Mr. John White of Aberdeen, who has been the longest and most successful user of rubber-tyred engines in England. From 1870 to 1878 (both years inclusive), his engine was 2207 days at work, an average of 245 days per year. The miles run were 27,726. The tyres were repaired five times, about $\frac{3}{8}$ in. thickness being inserted into the tyres each time. The total wear was 49 per cent. of the whole weight of the tyres, or 1.75 per cent. per 1000 miles, which strikingly coincides with the other figures given in the Table.

As none of the tyres were renewed or repaired in India nothing was entered under that heat in the train accounts; therefore, to make Table II.B (the analysis of working expenses) complete, a figure has been added calculated from Mr. White's accounts of the cost of rubber-tyre repairs, *i.e.*,

$$\frac{170l.\ 16s.\ 7d.}{27{,}726} = 1.4d. \text{ per train-mile, or } 0.18d. \text{ per ton-mile.}$$

The total working cost is thus shown to be 26d. per train mile, or 3.45d. per ton mile of the paying loads actually carried which were in one direction only; under more favourable conditions as to back traffic the cost per ton-mile would be considerably reduced.

Speed and Regularity.—Table IV. shows the average speed, and number of delays from accident or other causes, during the same two periods in 1873 and 1874. The total shows 4.6 miles per hour as the average speed of loaded and empty trains between terminal stations. This includes all stoppages at intermediate stations as well as accidental delays. Every one of these, whether caused by the engine or train, or by repairs to the roads, are recorded against the train, and are included in the above average speed. If their regular and accidental stoppages be excluded, the travelling speed on the road was nearly four miles an hour for loaded trains, and eight miles for empty ones. In good weather the trains arrived to their time with great regularity. The two extremes of weather—heavy rains and long-continued drought—were equally against good timing; in the first case the driver had against him heavy roads and sopping wet wood for fuel for his engine; in the latter the road would be nearly as heavy from thick dust, which, rising in dense clouds, and penetrating to every bearing part, caused heating and cutting of the surfaces if speed was attempted.

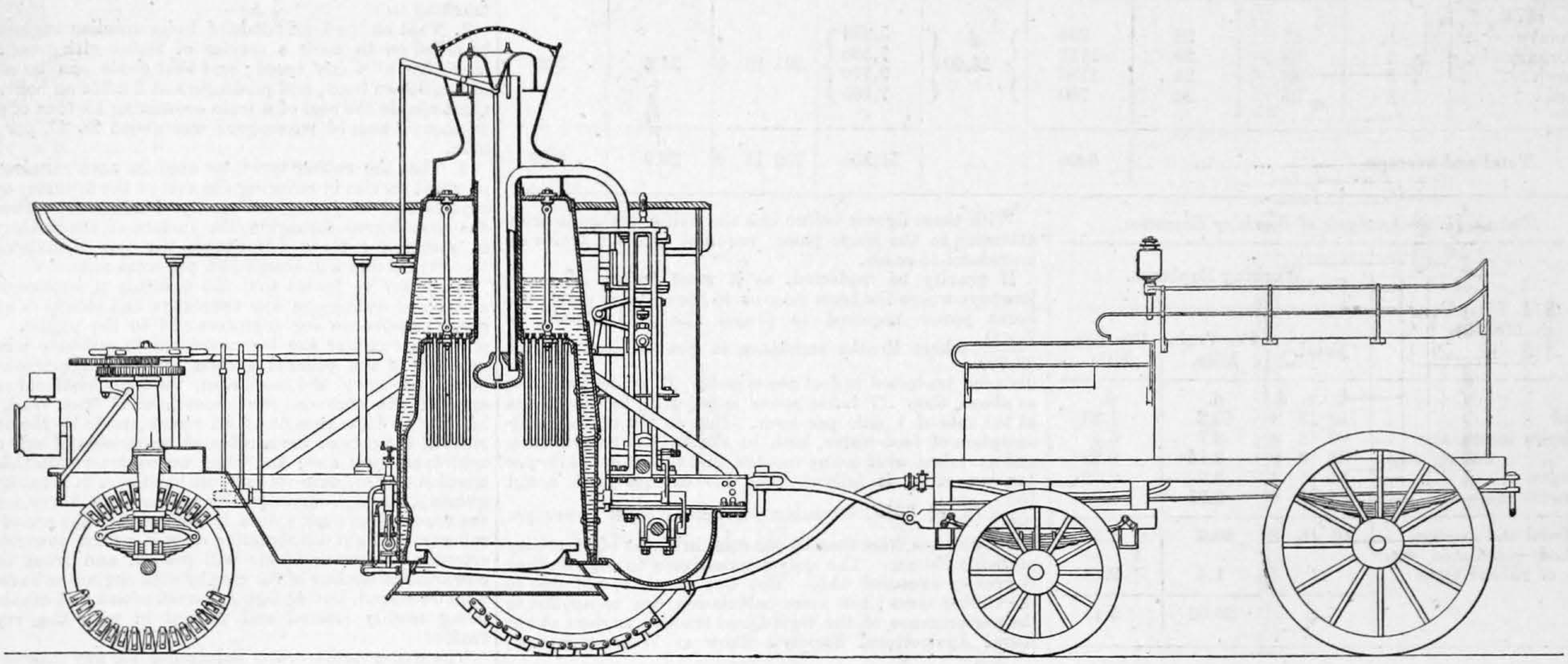
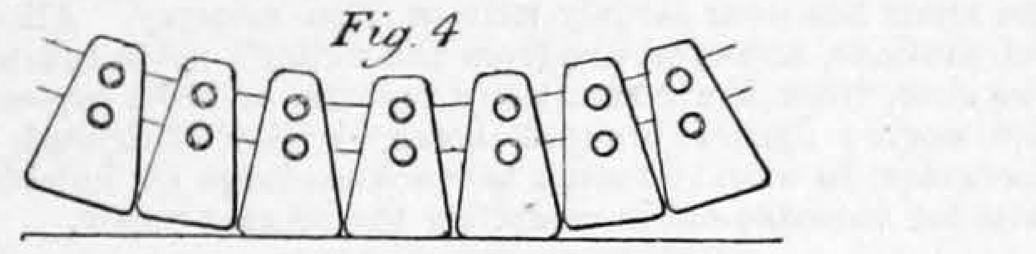


Fig. 4



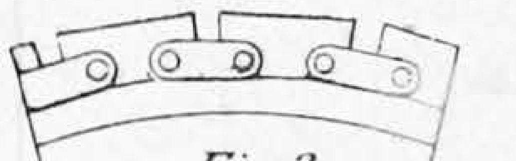


Fig. 3

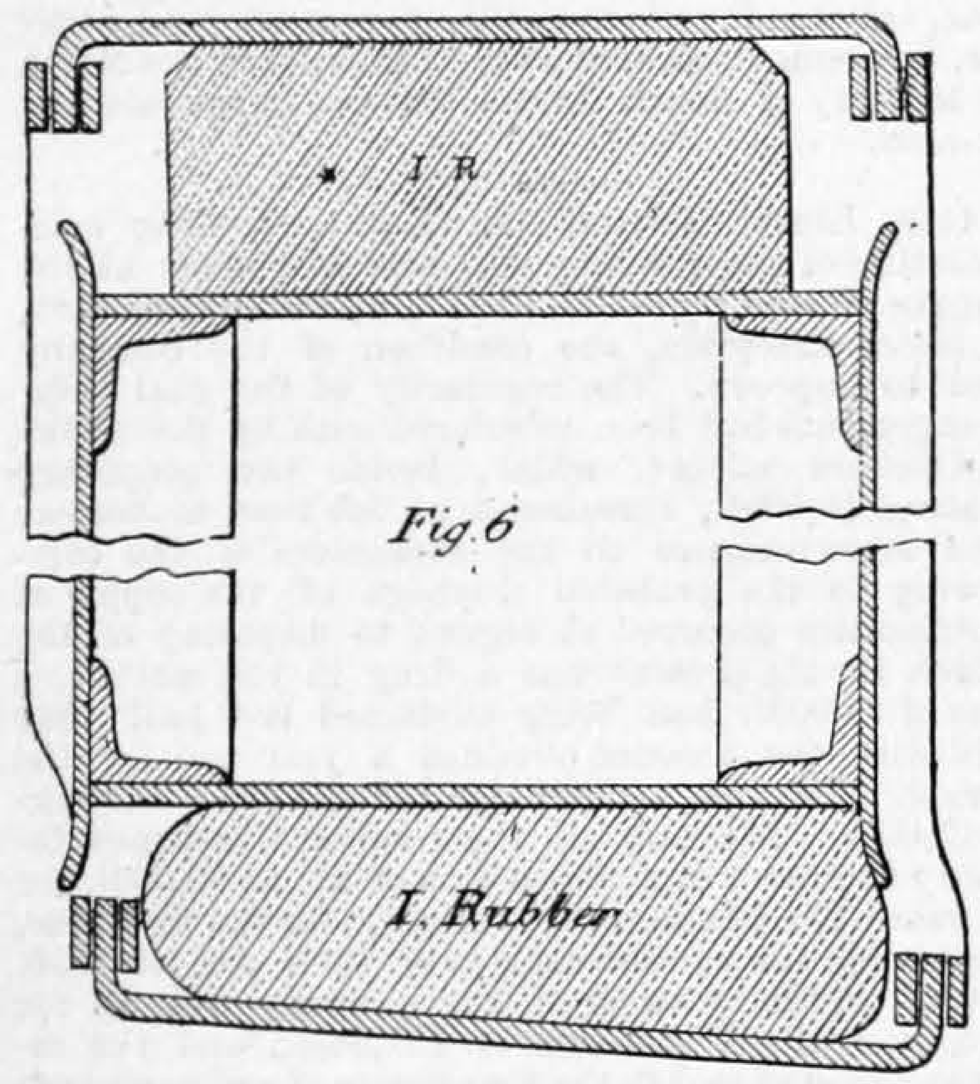


Fig. 6

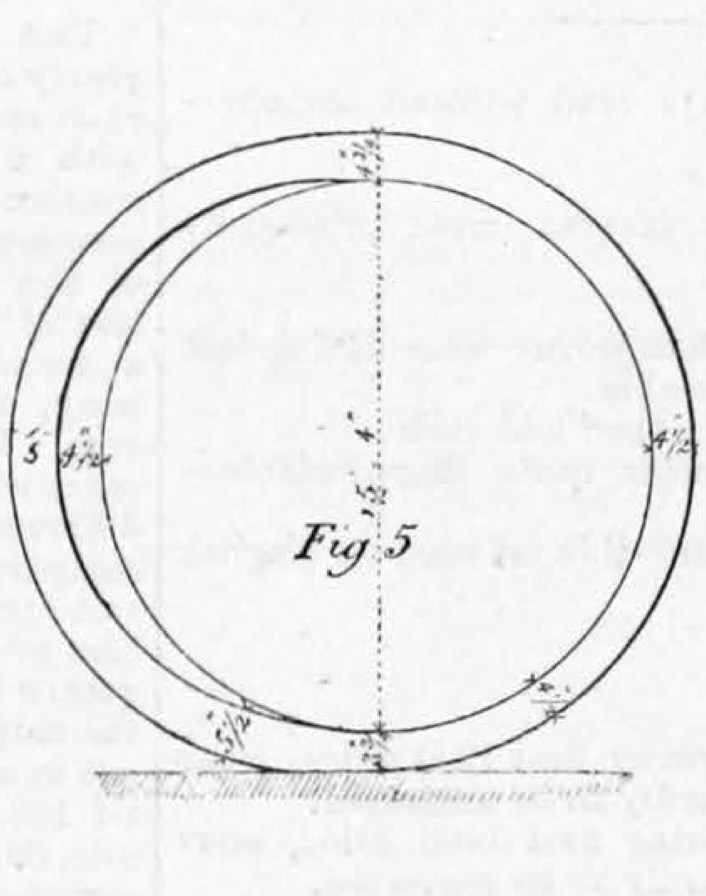


Fig. 5

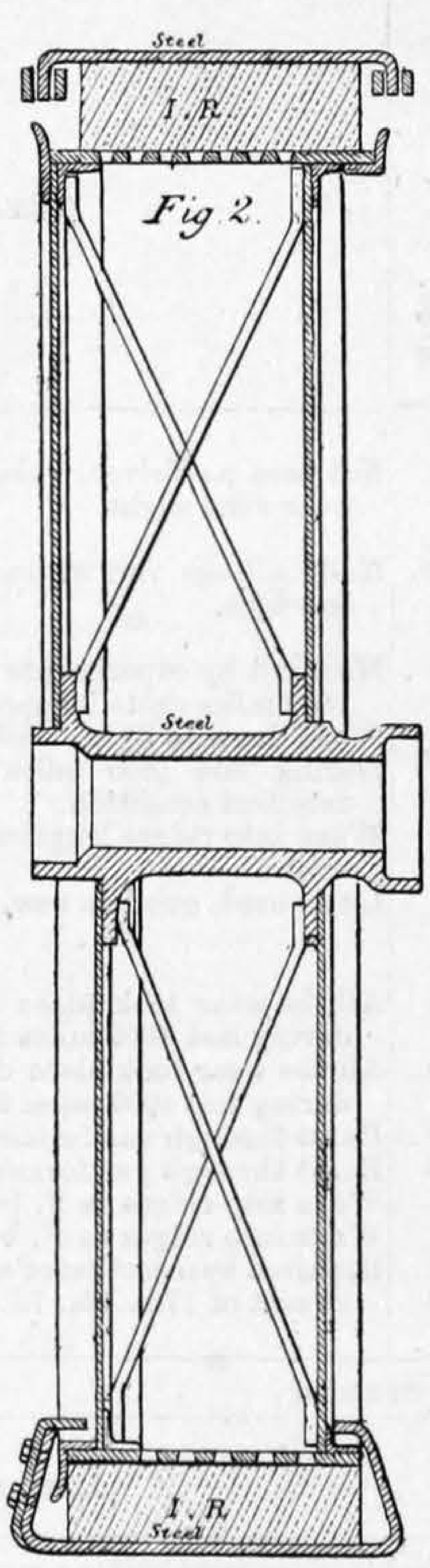


Fig. 2

As the wear of the rubber tyres is not the least interesting part of the results arrived at, it has been kept separate from the other accounts. Table III. shows the mileage run on seven pairs of driving-wheel and six leading-wheel tyres, lettered from A to N consecutively; it shows also the percentage of wear per 1000 miles, and the insistent weight per square inch of cross section in each case. It is very instructive to notice how intimately the rate of wear is connected with this last figure. When the engines carried their own fuel and water the weight per square inch was for the driving wheels $\frac{10.25 \times 2240}{15 \times 4\frac{1}{2} \times 2} = 170$ lb.; while after the water tanks and bunkers were removed it was $\frac{7 \times 2240}{15 \times 4\frac{1}{2} \times 2} = 116$ lb. In the former case the rate of wear (calculated on the D and F sets of tyres) was 6.85 per cent. per 1000 miles; in the latter case (calculated on the average of the C and E sets) it was 1.75 per cent. per 1000 miles. The same calculation approximately holds good for the leading-wheel tyres, but to a still greater extent; the load of 169 lb. per square inch of section seeming to have a rapidly destructive effect on these tyres of smaller diameter. No doubt this was in proportion as the number of compressions per minute were greater. The figures give the actual average wear of the tyres from first to last. The tyres were often measured and weighed, and notes taken from time to time of their lessened weight. These notes, partly taken by the writer, and after him by Mr

Load.—During the sitting of the committee in October, 1873, a trial was carried out to show the hauling capability of the engines on the steepest inclines of that section of the Trunk road. The train consisted of the engine "Indus" (weight empty, 8 tons 8 cwt.; full, 9 tons 11 cwt.), a tender and fourteen vehicles, four-wheeled and two-wheeled, arranged alternately. The total weight of the empty train, including engine, was 28 tons 8 cwt.; the total weight of load carried was 50 tons 6 cwt.; and thus the total gross weight of the train was 78 tons 14 cwt.

The gradients on the incline were ascertained to be 2.4 per cent. in the first 100 ft., 3.0 per cent. in the second, 2.5 per cent. in the third, and so on. The steepest length on which the train could be at one time had a slope of 2.66 per cent., giving $78.7 \times 2240 \times .0266 = 4580$ lb. as the draught of the train due to gravity.

The draught of the train or resistance due to friction is not easy to ascertain exactly. For a macadamised road, with good foundation and smooth surface, various writers have given figures varying from $\frac{1}{30}$ to $\frac{1}{40}$, or from 75 lb. to 55 lb. a ton. The trials of the draught of carts and wagons by the Royal Agricultural Society of England showed even a smaller resistance than 55 lb., but as these were for singled picked vehicles, it is probable that so low a figure is seldom obtained. In the case of the trial described, in order to get the load on to the train, every vehicle was loaded until the springs were down, the axles were forced out of square with their bodies, and the axle arms considerably sprung. It would therefore be not unfair to suppose that the resistance was in this case 64 lb. per ton, or 5000 lb. for the entire train. Adding this figure to that due to gravity, we get 9580 lb. as the total resistance of the train to be overcome at the peripheries of the driving-wheels.

The weight on the driving wheels was carefully ascertained to be 15,680 lb., therefore the adhesion developed on this trial was $\frac{9580}{15{,}680}$ or .61. The total length of this incline was 5321 ft.; the distance was traversed in 12 min. 6 sec., or at the rate of five miles an hour nearly; and the vertical height through which the train was raised was 66 ft. Taking the above figures for gravity and frictional resistance, we find that the engine developed 96 horse power actual. The boiler made steam freely, and there was ample cylinder power to utilise the adhesion.

TABLE II.a—Working of Engines in First Four Months of 1873 and 1874.

Date.	Number of Engines at Work.	Train Mileage. Number of Trips.	Train Mileage. Average Length.	Train Mileage. Train Miles.	Ton Mileage. Average Net Load.	Ton Mileage. Ton Miles.	Working Expenses. Total.	Working Expenses. Per Train Mile.	Working Expenses. Per Ton Mile.
1873.			miles.		tons.		£ s. d.	d.	d.
January ...	2	44	$14\frac{3}{4}$	648	16.12	4,500	317 18 4	28.2	3.39
February ...	2	24	$22\frac{1}{2}$	539		4,700			
March... ...	1	24	$28\frac{1}{2}$	687		5,160			
April	1	29	$28\frac{1}{2}$	825		8,130			
1874.									
January ...	1	27	28	734	15.00	5,250	391 16 8	24.6	3.27
February ...	2	38	29	1121		7,180			
March... ...	2	48	24	1156		9,170			
April	1	35	22	780		7,165			
Total and average				6490	...	51,255	709 15 0	26.0	3.32

Table II.b—*Analysis of Working Expenses.*

1874. First Four Months.	Working Expenses. Total.	Per Train Mile.	Per Ton Mile.
	£ s. d.	d.	d.
Fuel	159 13 4	10.2	1.33
Repairs to engines ...	60 2 4	3.7	0.5
,, rolling stock	34 6 8	2.15	0.28
Wages	44 3 4	2.7	0.37
General charges ...	93 11 0	5.85	0.79
Total and average ...	391 16 8	24.6	3.27
Add calculated wear of rubber tyres ...	...	1.4	0.18
	...	26.00	3.45

With these figures before him the writer wishes to draw attention to the horse power required to draw trains on macadamised roads.

If gravity be neglected, as it must be on all-round journeys where the train returns to the starting point, the horse power required to propel the train should be $\frac{R \times D}{33,000}$, where R=the resistance in pounds, and D=the distance traversed in feet per minute. If we make R=64 as above, then .17 horse power is required to draw 1 ton at the rate of 1 mile per hour. But as the average consumption of feed-water, both in the English experiments, and as taken over many months in India, was 13 lb. per ton per mile, it follows that the engines used about $\frac{100}{17} \times 13$, or 76 lb. of water per actual horse power per hour, which is more than 80 per cent. in excess of what they probably did use. The only alternative is to suppose that R greatly exceeded 64 lb. But this excess is not due to the rubber tyres; the same calculation can be applied to the performance of the rigid-tyred traction engines at the Royal Agricultural Society's Show at Wolverhampton; from 11 lb. to 14 lb. of water per ton per mile was used by them.

Further the writer, being unable to obtain in India a suitable dynamometer, undertook a series of trials to obtain with tolerable correctness the frictional resistance of the trains and engines. Trains of known weight were brought to a standstill on an incline on a road of very good surface and regular gradient; the exact gradient was noted at which gravity was able to overcome the resistance of the train, which included the friction of the engine in gear, and the resistance thus found certainly did not exceed 74 lb. a ton. This apparent paradox is well worth the attention of engineers interested in this matter.

Conclusions. — The writer has endeavoured to show that this series of experiments has been of service in teaching us:

1. That on the level roads of India traction engines can be relied on to work a service of trains with great regularity and at a fair speed; and that goods can be carried at 4 miles an hour, and passengers at 8 miles an hour. At these speeds the cost of a train containing 15 tons of goods or about 7 tons of passengers was about 2s. 2d. per train mile.

2. That the rubber tyres, as used in such running, are of great service in reducing the cost of the ordinary engine repairs and in giving uniformity of adhesion, without in the least degree damaging the surface of the roads; that in return for these advantages the cost of maintaining these tyres does not exceed $1\frac{1}{2}$d. per train mile.

It cannot be denied that the question of improved and cheapened haulage on our tramways and streets is one of great importance for engineers and to the public. Now when we consider the inconvenience to ordinary wheeled vehicles of the present system of tramways when laid down in crowded thoroughfares, the high frictional resistance of the cars on the unmechanical tram rail, the liability to derangement of all street traffic by the derailment of the cars or the accidental breakdown of any other vehicle on their line; and when we contrast with this the traction engine, with its extreme handiness in turning and steering, its high adhesion, its minimum of harm done to the road surface, &c.; does it not point to the use of real railways of light construction carried as far towards the crowded centres as traffic will permit, and from thence onwards the hauling of the cars by such engines as have been here described, but of lighter construction and capable of being readily steered and worked in with the regular traffic?

The writer must crave indulgence for any inaccuracies which may have crept into this narrative, as the history of the trials has been largely written from memory. All the calculations, however, are from the writer's notes taken at the time, from the committee's reports, or from copies of the engine diaries brought home by Mr. Muirhead, his successor, to whom he must here acknowledge his indebtedness for valuable aid in compiling the present paper.

TABLE III.—Mileage, &c., Insistent Weights and Rate of Wear of Rubber Tyres.

Description of Wheel and Tyre.	Letter.	Mileage.	Weight on each Square Inch of Cross Section.	Fraction of Thickness Worn Off—Total.	Fraction of Thickness Worn Off per 1000 Miles.	Remarks.
		miles.	lb.			
Omnibus 5 ft. in diameter	A	11,200	140	.08	.0072	Not used as drivers—always used without armour—wear very slight.
Eight horse power 5 ft. in diameter by 12.4 in. ...	B	2,800	135	.032	.0114	Half mileage run without armour—wear principally on edges.
Fourteen horse power engine, driver 6 ft. in diameter by 15 in. by $4\frac{1}{2}$ in.	C	4,800	116	.084	.0175	More cut by experiments than worn—wear during last 1400 miles quite inappreciable.
Do. do.	D	4,200	170	.22	.0525	Worn down to $3\frac{1}{2}$ in. thick; then laid aside.
Do. do.	E	3,200	116	.054	.0169	During last 1800 miles wear quite inappreciable—excellent condition.
Do. do.	F	4,000	170	.32	.08	Worn into ridges lengthwise—this set used on English trials.
Do. do.	G	200	165	.32	.08	Little used, good as new.
Fourteen horse power steering wheel 4 ft in diameter by 12 in. by 4 in.... ...	H	6,100	119	.094	.0154	All the wear took place during first 1200 miles, wear during last 4000 miles hardly to be measured.
Do. do.	I	4,950	119	.064	.0130	All the wear took place during first 1400 miles, wear during last 4000 miles hardly to be measured.
Do. do.	K	450	169	.064	.0130	Burst through gas forming in substance of the tyre.
Do. do.	L	650	169	.064	.0130	Burst through gas forming in substance of the tyre.
Do. do.	M	1,100	169	.43	.392	Worn into ridges as F, but in transverse direction.
Do. do.	N	900	169	.45	.5	Worn into ridges as F, but in transverse direction.
Mr. White's, 6 ft. diameter by 15 ft. by $4\frac{1}{2}$ in. ...	O	27,726	130?	.49	.0178	Repaired by insertion of a lining five times in nine years at cost of 170*l.* 16s. 7d.

TABLE IV.—Speeds.

Year and Month.	Train Miles.	Hours on Road.	Average Speed. Miles per Hour.	Remarks.
1873. January	648	112	5.6	Eight delays from trifling causes, total 14 hours—two men run over.
,, February	539	122	4.4	Two delays, 9 hours—malicious accidents.
,, March	687	172	4.0	One delay, 4 hours—plummer block collar broke.
,, April...	825	204	4.0	Thirteen delays, $9\frac{1}{2}$ hours—all attributable to worn state of armour.
1874. January	754	167	4.5	Three delays, 9 hours—principally due, as above, to armour.
,, February	1121	255	4.4	No delays—weather very heavy.
,, March	1156	196	5.9	No delays, fine weather and long trips, steady running.
,, April...	780	188	4.1	Three delays—accidents to rolling stock—otherwise good running.
Total	6510	1416	4.6	

South African Stone.—A quarry containing excellent stone, suitable for window sills, pavement, and other purposes, has been discovered at the 84th mile on the North Eastern Railway of South Africa between Alicedale and Riebeck-road.

The Gas Light and Coke Company.—The half-yearly meeting of the company was held last week at the chief office in Horseferry-road. The accounts showed that, with a slight exception, the condition of the company continued to improve. The regularity of the coal shipping arrangements had been interfered with by the strike of the Durham miners, which, beside the pecuniary loss of about 16,000*l.*, threatened at one time to become a serious inconvenience to the consumers of the company, owing to the probable stoppage of the supply of coal. Difficulties occurred in regard to disposing of the coke, which for the present was a drug in the market, a difference of 23,000*l.* loss being sustained last half year compared with the amount obtained a year ago for the same period. The sum realised for tar showed a diminution of 17,000*l.* Massing all the comparative losses together they showed a diminished sum of about 60,000*l.* for the half year. The directors had recently, for the first time, put in operation the auction clauses of their Act of 1876. Of 100,000*l.* ordinary stock of the company put up for sale, 69,500*l.* realised the sum of 121,865*l.*, and the remainder had been offered to the proprietors of ordinary stock at the price of 175*l.* for each 100*l.* issued. Applications had been received far in excess of the balance remaining to be allotted. The total sum paid to the company thus acquired amounted to 175,240*l.*; the premium of 75,240*l* would be applied to extending or improving the works of the company, and would not be treated as part of the capital subject to a dividend. The half-yearly working had resulted in a profit which, after providing for all preferential claims, would allow of a dividend for the half year at the rate of $10\frac{1}{2}$ per cent. per annum. The chairman, after entering into details of the accounts referred to in the report, drew attention to the remarks of the Select Committee of the House of Commons on electric lighting which have already appeared *in extenso* in our columns. After adversely criticising the report, he stated that he had never apprehended any danger to the interests of the gas companies since he had first seen the electric light in Paris some 18 months ago. It could not be applied successfully as a substitute for gas in a financial point of view. To compete with the electric light the Gas Light and Coke Company had made a demonstration to the public of what might be done with gas, although certainly at a greater expense above that of the old system, and referred to the light they had placed at the foot of Westminter Bridge and in direct contiguity with the electric light. He also referred to the improved lighting of Queen Victoria-street in the City and other parts of the metropolis. After the usual vote of thanks, the meeting separated.

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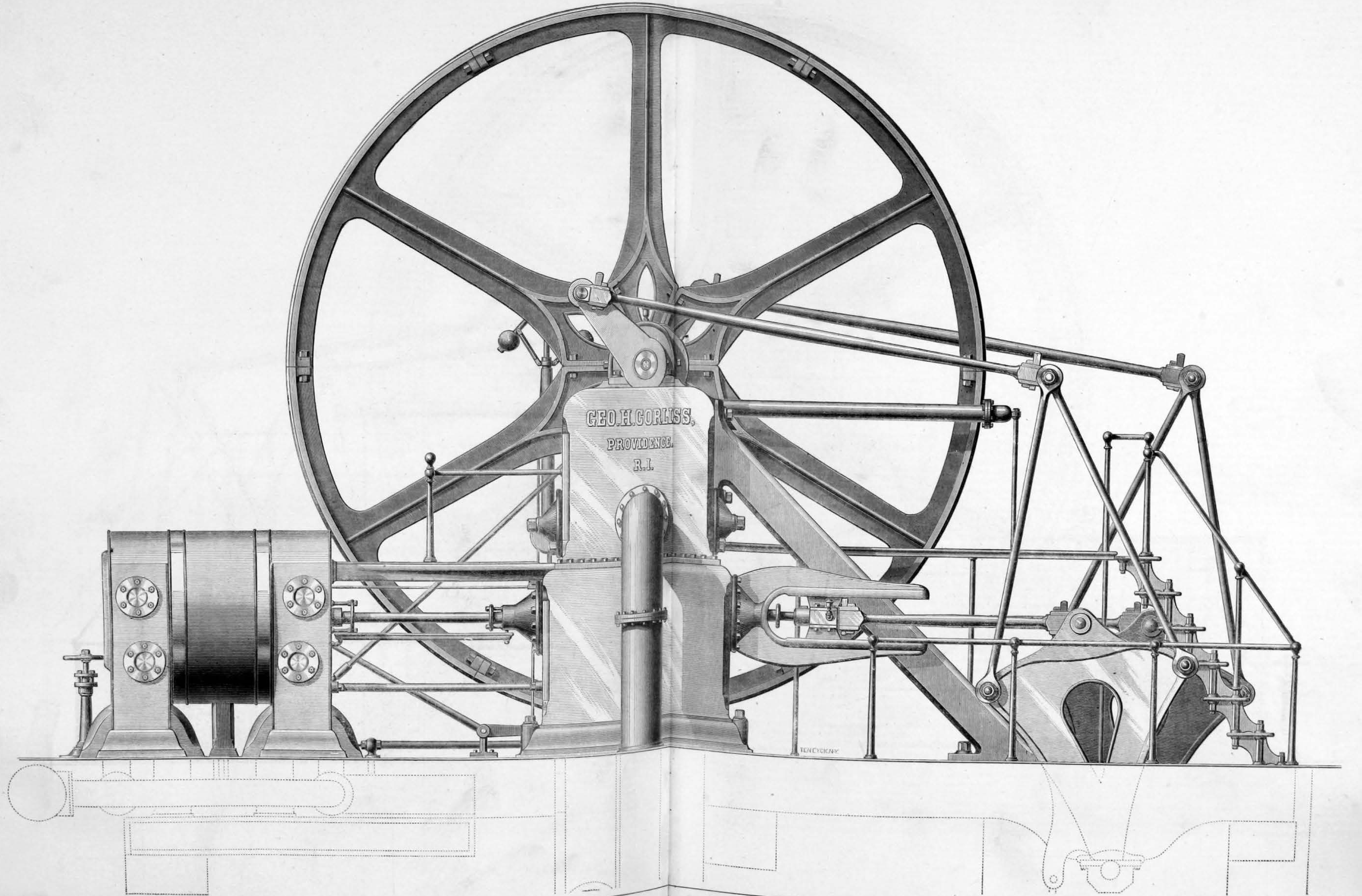
DESIGNED AND CONSTRUCTED BY MR. GEORGE H. CORLISS, ENGINEER, PROVIDENCE, RHODE ISLAND, U.S.A.

(*For Notice, see Page 154.*)



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ENGINEERING.

FRIDAY, AUGUST 22, 1879.

THE ASSIMILATION OF PATENT LAWS.

It has long been felt there should be an assimilation in the law and practice in regard to inventions amongst the various civilised countries of the world. The English Select Committee on Letters Patent in 1872 not only reported in this sense, but went so far as to say Her Majesty's Government should be requested to inquire of foreign and colonial governments how far they were ready to concur in international arrangements in relation thereto. In 1873, the Vienna Patent Congress, after stating that the protection of inventions should be guaranteed by the laws of all civilised nations, expressed the opinion that considering the great differences in patent administration and the altered international commercial relations, the necessity of reform was evident, and it was of pressing moment that governments should endeavour to bring about an international understanding upon patent protection as soon as possible. In 1875 the subject was brought before the Hague Conference of the Association for the Reform and Codification of the Law of Nations in a paper by Mr. Lloyd Wise, when an influential committee was appointed to consider and report on that and other matters. The committee was divided into sections, and at the subsequent conference the members of the patent section were appointed a separate committee, with power to add to their number, and this committee gradually became large and powerful. We now have before us the result of its labours in the shape of a report signed by Mr. A. H. Brown, M.P., as chairman, and Mr. Joseph G. Alexander, L.L.B., as honorary secretary. This report was presented to the conference held last week in the Guildhall, under the presidency of Sir Travers Twiss, D.C.L., F.R.S. The committee, after having deliberated on the subject, recognise that it seems impossible at the present time to propose one common law upon patents for inventions, on account of the numerous points of contact which the subject presents with divergent civil, commercial, and criminal law in general; nevertheless, it is advisable to select a certain number of general principles which may be accepted in the laws of all countries. It would occupy too much space to give all the resolutions in full, and it is the less needful to do so, since, in some measure, they agree with resolutions of the Paris Congress of 1878, already fully noticed by us. But the resolutions arrived at by the committee, and which were adopted last week by a special sectional meeting, and, finally, by the conference itself, deal with the whole subject in a more complete and practical manner than the resolutions of the Paris Congress, which, however, it is right to say, remain to be supplemented by the permanent commission appointed for that purpose, and which is composed of a number of sections, the English one consisting of Admiral Selwyn (chairman), Sir Henry Bessemer, Sir William Thomson, Mr. Gorst, Q.C., M.P., Mr. Olrick, Mr. Lloyd Wise, and Mr. J. G. Alexander (hon. sec.). Of these, five were members of the committee whose report is now under notice. One of the conclusions is that a temporary privilege of sufficient duration to insure the remuneration of their labours and outlay should be accorded to inventors, less in their own interest than in that of industry in general. This may be taken as having been pretty generally admitted, since most civilised countries, having already patent laws of some sort, have recognised the expediency of granting protection for inventions, and it may safely be affirmed such protection was not instituted for the peculiar benefit of inventors. It is recommended that the fees levied on patents should not be larger than is necessary to cover the expenses of the Patent Office, and should be levied by periodical payments. If the theory be true that a patent is a privilege given in exchange for an invention disclosed or developed by the grantee, and that the people at large benefit by the acquisition of inventions in this way, it is clearly illogical, not to say inexpedient, to specially tax the patentee, because, just in proportion as this is done, there is a lessening of the inducement held out to those who may have valuable inventions to disclose. We are not of those who believe that high fees weed out nothing but tares, or even that they do weed out the tares. The proportion of unmeritorious inventions patented in countries where the fees are light, is not greater than in this country, where the fees are heavy. But heavy fees keep many meritorious inventions out of the field, and from this cause the public is a considerable loser. It is not in the public interest that patents should become the luxury of the well-to-do, and be beyond the reach of inventors of limited means. This has been more than once fully recognised, and if, in saying the fees levied on patents should not be larger than is necessary to cover the expenses of the Patent Office, the committee appear to have left the matter, in one sense, in a rather indefinite state, it must not be overlooked that their resolution clearly indicates the principle that ought to govern each state in determining the amount of the fees to be charged, or that the Select Committee of 1872 deemed it sufficient to make the much less definite recommendation that the duties payable on patents should be so adjusted as to encourage inventors to the utmost to make known their inventions, and that their primary application should be to the purposes of a complete and well-organised record of industrial progress, and to an improved establishment for the conduct of patent business. Periodical payments are advisable, because they serve to remind the patentee, if inclined to be negligent of his invention, and it is from the activity of the patentee in getting his invention into practical use, even more than from the mere origination of the invention itself, that the public derives substantial benefit. The public must be educated to appreciate a new thing, the market must be created, and this is the most serious task the patentee has to perform. He confers no substantial benefit on the public by merely taking out a patent for a thing, be it ever so good, and resting on his oars, either in the hope that some one will go and ask him for it, or until it happens he is able to pounce upon some other inventor who may bring the thing out in an improved form, and actively and successfully promote its introduction commercially. The committee recommend that, in the absence of fraud, the first applicant should be deemed the inventor, and that no person, except he be engaged in the Patent Office, should, by reason of his employment, be debarred from obtaining patents for his own inventions. The granting of provisional protection in respect of patentable inventions exhibited at international exhibitions, or such as are officially recognised, is approved, and it is recommended, contrary to a resolution of the Paris Congress, that the term during which inventions are thus protected should not be deducted from the term of the patent. Other resolutions are to the effect that provisional protection, for twelve months, should be granted on the applicant for a patent filing a provisional specification containing an outline description of the nature of his invention, in which no details should be required; that no description of the invention—except its name—should be published before the issue of the patent, except as mentioned below; that the deposit of provisional specifications should, if desired by the inventor, be allowed to be made at the authorised local office, and at the consulates of the various nations, and on such deposit at a consulate, and the payment of the patent fees, provisional protection should commence as if the deposit had taken place in the Patent Office of the country represented; that, prior to the expiration of the term of provisional protection, if the applicant desires to complete his patent, he should be required to file a full specification; that, where a patent has been applied for in one country, subsequent publication of the invention should not, during a period of twelve months, prejudice the original applicant's right to patent in other countries; and that, on the filing of the complete specification, or the expiry of the term of provisional protection, if no complete specification has been filed, the provisional specification should be published. After the filing of the complete specification, and previously to its publication, it is suggested, the Patent Office should examine it, having regard exclusively to whether the specification is clear; whether the invention is contrary to public morals; and whether the invention is wanting in novelty, regard being had solely to prior publications in the Patent Office of the country. For the purposes of examination, an invention should not be deemed to be wanting in novelty, unless a prior publication be found which comes strictly within one or other of the following conditions: *a*. It should be not more than twenty-five years old, and be in the form of a full description, identical with the applicant's description. *b*. If the prior description be more than twenty-five years old, it should be proved that the identical invention as claimed by the applicant has been openly used within twenty-one years last past. Should some parts of the invention come within these objections the applicant should be allowed to amend his specification; subject to such amendment, the patent should be granted, except in cases of fraud, or when the invention is contrary to public morals. Another resolution expressly states that the reports and opinions of examining authorities, as respects applications for patents, should not be open to the public: a point we have repeatedly urged in these columns.

In speaking of provisional specifications one is naturally guided by experience of the working of the English patent laws, and in this view the resolution above referred to cannot but meet with approval. The practice of requiring details in provisional specifications has, under some law officers, been carried much too far, so as to have caused embarrassment to patentees when preparing their final specifications. The difficulty appears to have arisen in consequence of Rule No. 10 of the Commissioners of Patents, dated October 15, 1852, going beyond the requirements of the Act of 1852 in calling for not merely a description of the nature of the invention, but one such as to apprise the law officer of the means by which it is to be carried into effect. Now, in practice, if an inventor be required to give these details it will frequently happen that his provisional specification will describe a different combination from that described in his final specification, because he is bound by law in that document to describe the best way then known to him of carrying out his invention, and the experience gained during the term of provisional protection will often have suggested the leaving out of some parts and the addition of others, so that if the provisional specification in the detailed form insisted upon by the authorities be strictly construed, the conclusion to be deduced must in such cases be that the invention claimed in the final specification is different from that disclosed in the provisional specification. The suggestion that the provisional specification should be published on the filing of the complete specification is one we made in reference to one of the recent Government bills, but in the matter of examination the committee's resolutions go somewhat beyond what we have suggested, though we are not disposed to take exception. It is undoubtedly advisable to put some limit upon the fatal consequences of prior publications, as if the mere existence of an old and practically forgotten description or specification of a patent taken out many years back, and which has expired, is to be fatal, even though the public has for years had the option of using the invention, and has failed to exercise that privilege, it seems to us the result must ere long be to strike a serious blow at industrial progress and prosperity, for nearly all inventions have been to some extent anticipated; but the descriptions, so long as they remain merely open to the world, so that there is no inducement to any one to practically develop and introduce the inventions indicated, are as pearls cast before swine. It is recommended that all patents be granted for a term of twenty-one years; that a patent should be held to confer an indefeasible title to the invention described in the complete specification, unless it be proved that there exists a prior patent covering an identical invention, or that the identical invention has been publicly used within twenty-one years prior to the date of the patent, or fully described in a publication bearing date or printed within twenty-five years prior to that date; that where it is proved that the public interest requires that a patent should be worked, and that the holder of the patent is not attempting to meet the demand, and refuses licenses, the Legislature should step in to prevent the public injury by a special law in each case; and that patents granted in different countries should be perfectly independent of each other in all respects. The suggestion as to working is satisfactory, inasmuch as it amounts to a distinct and emphatic protest against empowering any individual or body of persons short of the Legislature from interfering with patent property, and this is a point of far greater importance than many suppose. So important indeed is it, that, in view of what has recently taken place in a foreign country in reference to certain patents, we shall probably deal with the matter specially on an early day. Meanwhile we heartily congratulate the members of the Patent Law Committee of the Association for the Reform and Codification of the Law of Nations, on the satisfactory termination of their labours, and the comprehensive treatment the subject of patent law reform and assimilation has received at their hands. It is to be hoped their recommendations will receive the attention they so well deserve on the part of those interested in patent law reform.

THE BRITISH ASSOCIATION.

THE forty-ninth annual meeting of the British Association for the Advancement of Science which is now being held at Sheffield, commenced its session on Wednesday last at one o'clock P.M., by a meeting of the General Committee, when the Council's report for the past year, which we print on another page, was received and adopted, and the officers of sections were elected. We gave on page 132 of our last number a list of the officers of the different sections for the present meeting, but since that list was prepared, several additions have been made to the vice-presidents. Thus the names of Professor Abel, C.B., F.R.S., F.C.S., and of Professor Odling, F.R.S., F.C.S., have been added to Section B (Chemical Science); that of Mr. W. Pengelly, F.R.S., F.G.S., to Section C (Geology); those of Professor Westwood and Professor Newton, F.R.S., to Section D (Biology); that of Professor Leone Levi to Section F (Economic Science and Statistics); and those of Mr. William Barlow, F.R.S., and Sir Joseph Whitworth to Section G (Mechanical Science).

At two o'clock the committees of sections held preliminary meetings in their respective rooms for the purpose of considering such papers as had already been received, and for arranging the list of communications to be read the next day, when the real business of the meeting began in earnest.

The first general or inaugural meeting of the Association was held in the Albert Hall in the evening of Wednesday at eight o'clock, when the retiring President, Mr. William Spottiswoode, M.A., President of the Royal Society, resigned the chair into the keeping of the President elect, Professor G. J. Allman, M.D., F.R.S., who delivered the opening address.

Last night a conversazione of a brilliant character was given to the members and associates by the Master Cutler and the Cutlers' Company in the Cutlers' Hall, and this evening Mr. William Crookes, F.R.S., will deliver a lecture in the Albert Hall on radiant matter, which we shall publish *in extenso* next week, and in which some highly interesting facts and results will be announced. On Monday evening next there will be a discourse in the same hall by Professor E. Ray Lankester, F.R.S., on "Degeneration," and on Tuesday evening, the 26th instant, there will be a conversazione given by the Local Committee in the Cutlers' Hall. The concluding general meeting will be held at half-past two on Wednesday afternoon next, when the usual concluding formalities will be gone through, and the meeting will be adjourned until next year, when the annual meeting will be held at Swansea. In connexion with the present meeting at Sheffield, Mr. Ayrton, whose name is known in connexion with the advancement of Japanese science, will to-morrow evening deliver a lecture to working men in the Albert Hall on "Electricity as a Motive Power, with Illustrations, including Machinery in Motion, driven by Power derived from a Distance, and specially bearing upon Sheffield Trades."

There is, in connexion with the Sheffield meeting of the British Association, a larger number of excursions than usual, no less than thirteen such excursions being provided for Saturday next and eleven for the subsequent Thursday. As these are all pleasure excursions it is unnecessary for us to give details of them. In addition to these pleasure trips there will be excursions to different works, mines, and collieries in the neighbourhood of Sheffield, and most of the important iron, steel, and cutlery works, as well as other factories will be thrown open to members of the Association.

The meeting, so far as it has gone, appears to be a promising one, and some communications of a highly interesting character are in the lists of papers to be read.

WATER SUPPLY.

IT is somewhat remarkable that despite all the vaunted science of the nineteenth century, the question of national and local water supply of England yet remains to be discussed in reference to its final (if possible) solution. Barely second to the supply of air in quality and quantity are in importance the analogous conditions of water. The greater portion of humanity in its bodily existence is water. If this be inferior in quality the organisms and functions must suffer.

For several years past our columns have been devoted to discussing this subject, and therefore we are glad to find that, by recent events, the question, at least so far as London is concerned, has now apparently arrived at a kind of climax. In May, 1878, and in May of the present year, conferences were held by the Society of Arts at the instance of the Prince of Wales to discuss the question of what has been termed a "National Water Supply." In a recently issued report the Council of the Society of Arts has issued a pamphlet which, without exception, is one of the most valuable contributions that has yet been made to the literature of the water and sewage questions. In our last volume we gave a brief notice of the early and comparatively imperfect results of the conference held in last May. But in the work recently issued there is scarcely anything left untouched in respect to sanitary matters. Its contents may be briefly sketched. Various essays are given on the general question of dividing England and Wales into water districts, affording also maps, statistics of area, population, &c., to the latest possible dates. Among the papers read at the conference last May, some from the most eminent engineers, chemists, and medical officers, are given in regard to methods of securing a sufficient supply of pure water. Other papers on the evils of impurity and consequent connexion of the questions of water supply and sewage are published. The various methods of sewage disposal are stated and discussed; returns are given in respect to the condition and prospects of sewage farms. These with other communications on sanitary matters in general make the recently issued work a *vade mecum* to every sanitarian.

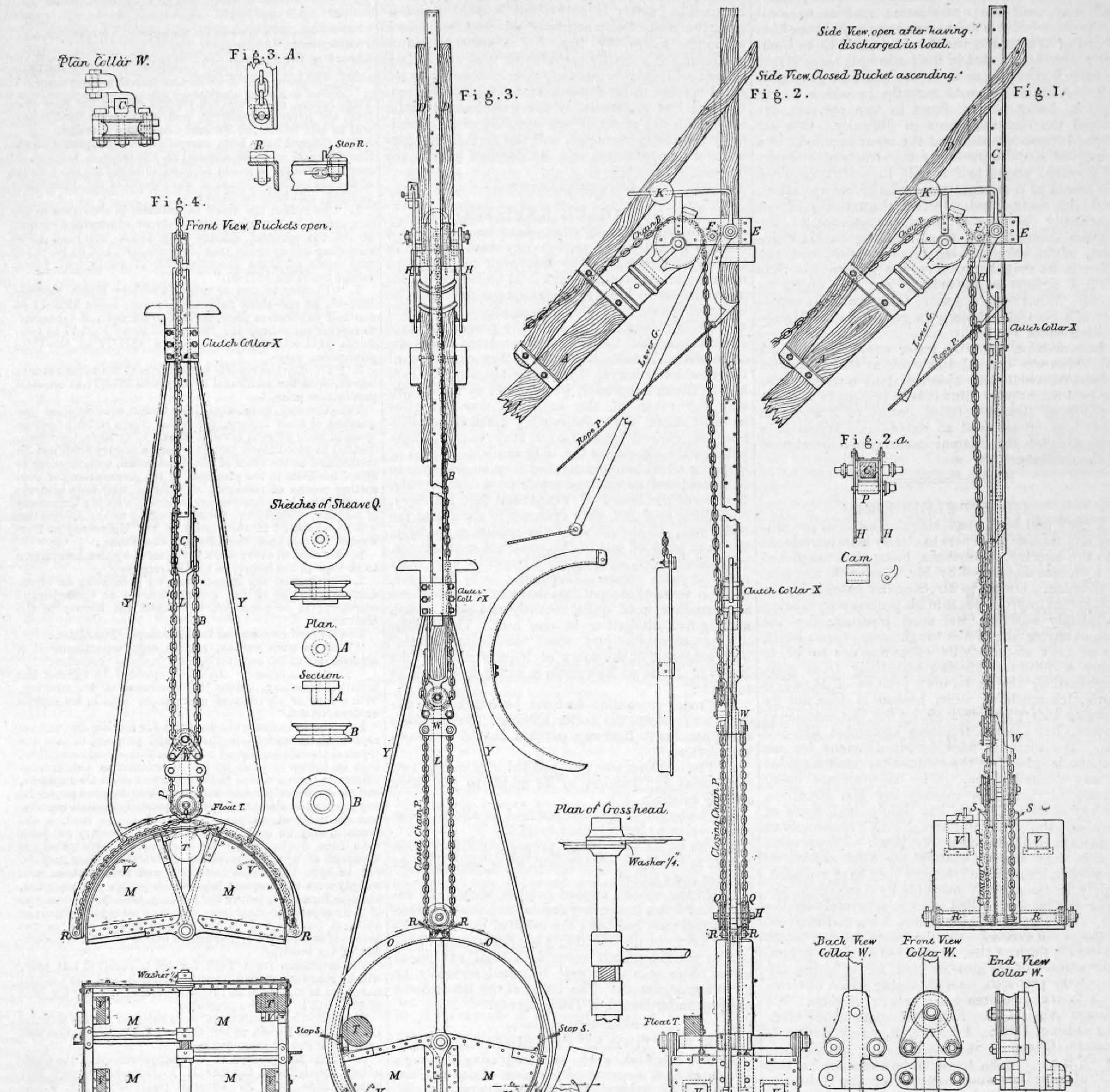
Parliament at last has taken up the question of the London water supply. On the 13th inst. Mr. Fawcett introduced his long-promised motion on the subject. After congratulating the Government on the fact that they had recognised the importance of the question, and thanking them for facilitating the discussion of his motion, he entered on its general details. Pure water affected the health of the community, and it was hopeless to expect temperance if pure water were not supplied. The practical questions were whether the quality of water supplied to London was sufficiently good; whether the mode of supply was what it ought to be; and whether the price was not excessive. In his opinion London was suffering far more from defects in the mode of supply, than from defects in the quality, because the best water from the purest spring might be polluted and hopelessly spoilt if stored as it is in the metropolis in tanks, cisterns, &c., open to every source of pollution. London obtains its supply from eight companies. But of these 51 per cent. of the supply was drawn from the Thames. Mr. Fawcett then entered into a variety of details to show the causes of pollution of London water which have been frequently discussed in ENGINEERING. The first thing to do was to improve the mode of supply, and next to perfect its source. He then urged the necessity of constant supply not only on the ground of health, but also as a prevention of large fires. He stated that before Manchester had a constant supply, 21 per cent. of the property attacked by fire was destroyed; since then the destruction was reduced to 6 per cent. The daily waste of water in London, owing to the intermittent system, was twice as great as in some towns possessing a constant supply. He then referred to the question of the charges for water in London, showing that in some cases persons renting houses at from 25*l*. to 30*l*. per annum, had to pay as much as eighteen pence in the pound rental for water, and yet had a wretched supply. In London the price of water rental was constantly increasing. In many instances the water rate had been doubled, and in some even trebled. He referred to the Valuation Act of 1869, which provided a fresh valuation each five years; a circumstance of which the water companies had taken every possible advantage, although the measure had been simply passed for the purposes of the poor rates. The Act had really been turned into a lever for increasing the profit of the London water companies, whose shares were constantly increasing in value. In respect to the shares of the New River Company, he drew attention to the enormous increase in their value of recent years. He objected to the monopoly of the water companies. In regard to gas the case was very different, as people had other sources of artificial light. But water was an absolute necessity, and its supply in London was now in the hands of those whose only object was to make profits without the slightest regard to the legitimate rights of their customers. The Metropolitan Board had already too much in hand, and he therefore urged on the Government to take the question up.

Mr. Sclater-Booth, on the part of the Government, admitted the truth of many matters urged by Mr. Fawcett, but to some extent apologised for the metropolitan water companies on the ground that they had effected many improvements during recent years, including better filtration, extension of the constant supply, &c. As regards the price of water charged in London, it was below that charged in some provincial towns. He agreed that the supply of water should be subject to the control of some central authority, and believed that efficiency and economy would result from following that course.

It was reserved for Mr. Cross, however, on the part of the Government to make a definite statement on the question. He admitted the truth of much that was urged by Mr. Fawcett. As regards the question of cost there was no power to control the existing companies so long as they kept within their statutory limits. He admitted that to place the water supply under the control of one central authority would tend to efficiency and economy. The Government had considered the matter most thoroughly, and had come to the conclusion that there were many reasons why the Metropolitan Board of Works was unfitted to undertake the control of the water supply of London, and the House had endorsed that view. One of the objections—and to his mind it was conclusive—was that the area to be supplied was larger than that of the Metropolitan Board. Under these circumstances what was to be done? He had already stated that the matter deserved not only serious, but immediate consideration. Things could not be allowed to rest as they were. But they must remember that they were dealing with an enormous population, and that a large amount of money had been expended by the water companies. If any such step were taken as was shadowed forth by the honourable member for Hackney, such a disturbance would be created

THE FOURACRES EXCAVATOR.

(*For Description, see Page* 157.)



in the shares and stocks as must inevitably result in injury. He (Mr. Cross) was as anxious as any one could be that the matter should be investigated, and that it should be investigated immediately. He would therefore undertake that the whole question should be looked into in all its bearings before the House met again, to see whether the supply of water could be effectually improved for the benefit of the inhabitants of London; whether, if that were done, it could be done without seriously increasing the cost of the supply to the individual consumer; whether the mode of supply could not be vastly improved; whether it would be necessary for the purpose that the whole of the water companies should—of course by agreement—surrender their powers to some body which should be appointed by the Government, and whether that would be the only way in which, if the companies were dealt with at all, they could be dealt with. All he could undertake to say was that before Parliament met again such an investigation should be made as would, in his opinion and in the opinion of the Government, satisfy both sides of the House. One thing must be made clear—that if the Government undertook to do anything they would take the companies as they found them, and no change in the action of the water companies would have the slightest effect upon the mind of the Government. He hoped every one would clearly understand that if the Government did undertake this scheme they would base their calculations on the state of affairs in the companies as they were on June 30th last.

This declaration on the part of the Government is, so far as it goes, decidedly satisfactory. We say advisedly—"so far as it goes"—simply because the limits of the inquiry are in the hands of the Government, who will naturally follow, to some extent, the course already laid out by preceding Commissions and other authorities. It must also be borne in mind that the water and gas interests in Parliament have great influence, and, under such circumstances, it must not be expected that any rash attempt will be made to injure the position or prospects of the holders of water shares.

We have to express the hope that we shall have no more Royal Commissions on the subject. The last report of the Rivers Pollution Committee treated the question of water supply almost exhaustively. If any additional information be required, it may be obtained from the report of the Society of Arts, which has been briefly summarised at the commencement of this article. The difficulty in respect to London is that there is no central authority of any kind. It has the Corporation of the City proper, the Metropolitan Board as a general authority, and the quarrelsome vestries as local authorities. But a week or so ago the Metropolitan Board of Works and the Gas Light and Coke Company were each foiled in their attempts respectively to carry out experiments in electric and gas lighting. A case appeared recently in which a City church, being bodily placed in two parishes, involved the churchwardens in difficulty. One set advised improvements, and the other opposed. An improved mode of sweeping the streets of one part of London, about half a mile in extent, required the assent of four separate vestries before operations could be commenced. In fact theoretically, if not practically (because of the inconvenience to the vestries themselves) a man, standing on his staircase, might have one leg in one parish, and the other in its neighbour. Truly, a government thus divided against itself neither can nor ought to stand. What facts can more fully prove the necessity of a central authority in regard to the Metropolitan water supply?

In connexion with the water supply question an exhibition was opened last week at the Alexandra Palace, Muswell Hill. This was done no doubt with the best intentions. But it is at present in so crude a condition that a detailed notice of it would do more harm than good to its object. When in a more complete state we purpose to give a description of the exhibits.

GLASS SLEEPERS.

A NEW and somewhat singular material for railway and tramway sleepers has lately been introduced into this country, this material being glass toughened by a process discovered by Mr. Frederick Siemens, of Dresden. Owing to Mr. Siemens' patents for the most recent improvements in his process not yet being completely secured, we must postpone for the present any details of the toughening process itself, but we may state that its effect appears to be to secure a product differing essentially from glass toughened by the well-known process of M. de la Bastie, inasmuch as when broken it does not fly to pieces like glass treated by the last-mentioned process, but merely fractures somewhat like cast iron. The material used by Mr. Siemens for his sleepers is glass of the commonest kind moulded to any desired form. The sleepers are being introduced into this country by Mr. Hamilton Lindsay Bucknall, who has lately laid some of them on the line of the North Metropolitan Tramways at High-street, Stratford. The sleepers in this case are of exactly the same section as the wooden longitudinal sleepers they have replaced, namely rectangular, 4 in. wide by 6 in. deep, the upper side being moulded so as to accurately fit the rails. They are laid in lengths of 3 ft., and to avoid the danger of settlement at the joints, bearing plates 10 in. by 5 in. by 1½ in. are placed at these points, these plates being also utilised for effecting the securing of the rails by a fastening which obviates the necessity of moulding any hole in the glass. We may add that samples of the sleepers above mentioned have been tested by Mr. Kircaldy, and their average breaking weight when resting on supports 30 in. apart has been found to be about 5 tons, this being probably about two-thirds of the resistance which would be afforded by a good pine sleeper of similar dimensions. It must, however, be borne in mind that whereas the timber would become depreciated by use, the glass promises to be practically indestructible by moisture, &c.

At the works of Mr. William Henderson, a plate of Mr. Siemens' toughened glass 9 in. square by 1⅛ in. thick, imbedded in gravel ballast 9 in. deep, and having on its top a wood packing ⅛ in. thick, and a piece of rail, was subjected to the action of a falling weight, the blows being delivered on the rail. The weight was 9 cwt., and blows were successively delivered by letting this weight fall from heights of 3 ft., 5 ft. 6 in., 7 ft., 10 ft., 12 ft. 6 in., 15 ft., 17 ft. 6 in., and 20 ft. Under the last mentioned blow the rail broke, the glass, however, being uninjured. As a higher fall could not be obtained, and a greater weight was not available, a smaller section of rail was substituted for that previously employed, and the glass was broken by a second blow of the 9 cwt. falling 20 ft., the plate being driven through the ballast into the hard ground. A cast-iron plate, 9 in. square and ½ in. thick, tested in a similar way, broke with a blow from the 9 cwt. weight dropped 10 ft.

The cost of the toughened glass is stated to be about the same per ton as that of cast iron, but as its specific gravity is only about one-third that of iron, the cost of any article of given dimensions is of course materially less. The material has as yet been too recently introduced, and too little is known of its characteristics, to enable any very decided opinion to be formed as to its future capabilities; but the results of the experiments so far made with the material are certainly of an exceedingly promising character, and the further development of its application will be watched with much interest.

FATAL BOILER EXPLOSIONS.

RAIN-drops do make impressions on stone, but it takes a long time to produce any marked effect in this way. It seems to us that even as rain-drops upon mountain masses, so are fatal boiler explosions upon the stony heart of a commercial public. The boiler of the steamer Black Swan exploded a month ago, killing four men. Now the remarkable fact about this is that the explosion occurred about the same place, Yarmouth Roads, as the explosion of the Druid's boiler in 1872; the inquest was held before the same coroner, we suppose, at Yarmouth, and the cause of the explosion was the same in both cases, the reprehensibly careless application of cupped patches over stay ends. These patches are sometimes the only available means of stopping a leak temporarily, but they ought never to be considered an efficient repair of a boiler. Mr. Samson of the Board of Trade, and Mr. Flannery, consulting engineer, gave evidence to show that the boiler was, at the place of the explosion, namely, the back plate of one of the combustion chambers, very much worn, and the plate ought to have been renewed years before. The boiler is 8½ years old, and for years these patches have been added one after another, until quite recently two were added, making five altogether in one nest. The verdict of the coroner's jury was "accidental death." The judgment of the court of inquiry held by the Board of Trade at Newcastle is under five heads as follows:

1. Proper precaution had not been taken by the engineer to keep the boiler efficient, the evidence being conclusive that cup patches should not have been left on.

2. The engineer was not justified in allowing two contiguous cup patches to be added to the three already existing.

3. The engineer was not justified in allowing the safety valve to be weighted to 54 lb.

4. The boiler was not in proper condition upon arrival in the Tyne in May last, when the last two patches were added.

5. On the whole, cupped patches should be regarded as but a temporary repair, and the sanctioning of their use had been the cause of the accident.

We have not the least doubt but that we shall have to give yet more such reports of fatal explosions before these monitions will be taken seriously by surviving engineers. The boiler of the Black Swan was not under Board of Trade survey.

THE PAWTUCKET PUMPING ENGINE.

WE give this week a two-page engraving showing a side elevation of a compound pumping engine at Pawtucket, U.S.A., designed and erected last year by Mr. George H. Corliss, of Providence, Rhode Island. The engine possesses some striking peculiarities, but we postpone our description of it and its performance until the publication of further engravings, which we shall give in an early number.

THE IRON AND STEEL INSTITUTE.

WE understand that the Iron and Steel Institute has received an invitation from some of the most influential steel makers on the Rhine to hold its autumn meeting of 1880 at Düsseldorf. The initiative in the matter has been taken by the members of the Iron and Steel Trade in that neighbourhood, who are also members of the Iron and Steel Institute. We also understand that in the autumn of next year an important Exhibition of Arts, Science, and Industry will be held at Düsseldorf, so that the time mentioned would be peculiarly opportune for the meeting of the Iron and Steel Institute. The members of the Institute will no doubt have the above-mentioned invitation submitted to them at their meeting at Liverpool next month, and we sincerely trust that it may be accepted. All familiar with Düsseldorf well know that it forms a most convenient centre from which excursions can be made to a number of important and interesting iron and steel works, while its position on the Rhine would readily enable a very pleasurable excursion of a less strictly professional character to be arranged for.

THE BRITISH ASSOCIATION.

Report of the Council for the Year 1878-9, presented to the General Committee at Sheffield, on Wednesday, August 20, 1879.

THE Council have received reports during the past year from the general treasurer, and his account for the year will be laid before the General Committee this day.

The Council have been compelled, in consequence of the limited space at their disposal at the office in London, to consider how far it would be possible to reduce the number of the old annual volumes of the reports of the Association in stock, and have resolved:

1. "To reduce the stock of volumes in each year to 200 in number, by throwing into waste or otherwise disposing of (as the general officers may think best) all those exceeding 200 up to the year 1848 inclusive, and by throwing into waste all those exceeding 200 in subsequent years, except the index 1831-61."

2. "To offer to one or more publishers single volumes 1831-48, at one-third publication price; those 1849-71 at one-half publication price, for which purpose, if necessary, to reprint the volume for 1850; and those 1872-77 at two-thirds publication price; also sets 1871-77 at one-third publication price."

3. "To offer the reports to members at the same rates as before, with the additional offer of sets 1849-71 at one-half publication price."

The Council have also had under consideration the question of their library, for which there is no adequate space in their present London office. They have, therefore, decided to recommend that in future a library shall not be maintained at the office of the Association, and, in order to afford facilities to the members of the Association for consulting works of reference as fully as they have hitherto enjoyed, they have made an arrangement with the University of London, whereby the books belonging to the Association will be deposited in the library of the University at Burlington House, upon the following conditions:

1. One copy of every book transferred by the Association to be kept in the library of the University.

2. Members of the Association, on presenting an introduction from one of the general officers or the assistant secretary, to be permitted to consult the library of the University.

The Council recommend to the General Committee:

"That in each section, and in each department of a section, one of the secretaries be appointed 'recorder.'"

"That such recorder shall be requested to furnish the assistant secretary, before the conclusion of the meeting, with a copy or abstract of every paper read in his section or department."

In order to increase the facilities for issuing the annual reports at an early date the Council propose, in case the General Committee should concur in this recommendation, that in future it shall be an instruction to the general officers to issue a notice to the reporters of all Committees, and to all other persons who are likely to read papers at any meeting of the Association, requesting that all reports, and abstracts of all papers intended to be read in the sections, may be sent to the assistant secretary not later than four weeks before the meeting, in order that, if approved of by the Organising Committees, they may be put in type before the meeting; and that authors who comply with this request, and whose papers are accepted, shall be furnished, before the meeting, with printed copies of their reports or abstracts; also that no report, paper, or abstract be inserted in the volume unless it is in the assistant secretary's or recorder's hands before the conclusion of the meeting.

The invitation from York for 1881, received last year, will be renewed on the present occasion, and the Council have also to announce an invitation from Leicester for 1882 or 1883 will be likewise presented.

The following resolutions were referred by the General Committee at Dublin to the Council for consideration and action if it should seem desirable.

1. "That the question of the reappointment of the Committee, consisting of the Rev. H. F. Barnes-Lawrence, Mr. Spence Bate, Mr. E. Dresser (secretary), Mr. J. E. Harting, Dr. Gwyn Jeffreys, Professor Newton, the Rev. Canon Tristram, and Mr. G. Shaw Lefevre, for the purpose of inquiring into the possibility of establishing a 'close time,' for the protection of indigenous animals, be referred to the Council for consideration; and that the Council be empowered to take such steps in the matter as they shall think most desirable in the interests of science."

The Council decided that the Committee should be reappointed, and that in case of any action being required before the next meeting of the Association, the Committee should be instructed to report to the Council thereon.

2. "That the attention of the Council of the Association be called to the fact that the recommendations of the Royal Commission on Science have been altogether disregarded in the Act lately passed to enable the Trustees of the British Museum to remove the Natural History Collection to South Kensington, and that the Council be requested to take such steps in the matter as they shall think most desirable in the interests of science."

The Council drew up a memorial to the First Lord of the Treasury, calling the attention of Her Majesty's Government to this question, and requesting Lord Beaconsfield to receive a deputation from the Council to present the memorial. Lord Beaconsfield having been obliged to decline to receive the deputation on account of the press of public business, the memorial was forwarded to him at his request, and a reply has been received, which, together with the memorial, is given in the Appendix (1) to this report.

3. "That the question of the appointment of a Committee, consisting of Mr. James Dillon, Mr. Edward Easton, Mr. P. Le Neve Foster, Captain Douglas Galton, Mr. T. Hawksley, Sir John Hawkshaw, Professor Hull, Mr. Robert Manning, Professor Prestwich, Professor Ramsay, Mr. C. E. De Rance, the Earl of Rosse, Mr. W. Shelford, Mr. J. N. Shoolbred, Mr. John Smyth, Jun., Mr. G. J. Symons, and Mr. A. T. Atchison (secretary), for the purpose of conferring with the Council as to the advisability of urging Government to take immediate action to procure unity of control of each of our principal river basins, be referred to the Council for consideration and action if it seem desirable."

The Council resolved that it did not seem to them desirable to take any action in this matter at present.

The Committee which was appointed last year for the purpose of watching and reporting to the Council on patent legislation made a report to the Council, which is given in Appendix II.

A deputation of the Council and certain other members of the Association waited on the Attorney-General on May 27th with the report, and urged the passing of the Patent Law Amendment Bill, with certain modifications. The Bill was subsequently withdrawn.

The Council announce with great regret the loss that they have sustained during the past year by the death of Mr. William Froude, F.R.S. One vacancy having been thus caused in their body, there remain only four names which it is necessary to remove from the list.

The Council propose that, in accordance with the regulations, the four retiring members shall be the following:

Mr. F. J. Bramwell, C.E., F.R.S.; Dr. W. Farr, F.R.S.; Mr. W. Pengelly, F.R.S.; Professor J. Prestwich, F.R.S.

The Council recommend the re-election of the other ordinary members of Council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list:

Ordinary Members of the Council.

Mr. F. A. Abel, C.B. F.R.S.; Professor W. G. Adams, F.R.S.; Mr. W. H. Barlow, F.R.S.; Professor Cayley, F.R.S.; Mr. E. Easton,* C.E.; Captain Evans, C.B., F.R.S.; Mr. J. Evans, F.R.S.; Professor G. C. Foster, F.R.S.; Mr. J. W. L. Glaisher, F.R.S.; Mr. J. Heywood, F.R.S.; Mr. W. Huggins, F.R.S.; Professor T. Hughes,* Mr. J. Gwyn Jeffreys,* F.R.S.; Mr. George Shaw Lefevre, M.P.; Professor N. S. Maskelyn, F.R.S.; Mr. W. Newmarch,* F.R.S.; Professor A. Newton, F.R.S.; Admiral Sir E. Ommaney, C.B., F.R.S.; Lord Rayleigh, F.R.S.; Professor G. Rolleston, F.R.S.; Professor H. E. Roscoe, F.R.S.; Dr. W. J. Russell, F.R.S.; Professor J. S. Burdon Sanderson, F.R.S.; Mr. Warrington W. Smyth, F.R.S.; Mr. H. C. Sorby,* F.R.S.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Market. — Yesterday there was a thin attendance on 'Change at Middlesbrough, but the tone of the market was better. Since our last notice there has been a gradual improvement in prices, and during the latter part of the week makers predicted that No. 3 Cleveland pig would be 35s. per ton on Tuesday. The market yesterday was certainly much stronger, but not quite equal to the expectations of makers. They asked 35s. net cash, and parcels changed hands at 34s. 6d. It is expected that with slight fluctuations the upward tendency will continue. Messrs. Connal and Co., the warrant storekeepers have in stock 81,900 tons in Cleveland, and they are receiving a small quantity of pig iron daily.

The Finished Iron Trade.—To-morrow the Board of Arbitration for the manufactured iron trade of the North England will hold a meeting at Darlington to discuss the proposed reduction of 15 per cent. in the wages of the higher paid workmen. Mr. David Dale, president of the British Iron Trade Association is arbitrator. After the Board have disposed of this question they will decide when they will meet to discuss the proposed general reduction of 5 per cent. in the finished iron trade throughout the North of England. Efforts will be made to get the matter speedily and amicably settled. There are firms who recently severed their connexion with the Board of Arbitration, so that they might deal with their men in their own way, and there are some firms connected with the Board who sometimes try the same thing. Although there is a surplus supply of labour in this country just now, the Board of Arbitration is certainly the most just tribunal for arranging the wages question, and when trade improves employers who have not been loyal to the Board, will not only recognise the justice and power of it but will seek readmission as members. In all departments the finished iron trade remains flat. From all parts the reports are more favourable, but there has been no practical indication of improvement here, prices being still low and orders most difficult to secure.

The Eston Steel Works.—Messrs. Bolckow, Vaughan, and Co. have given fourteen days' notice to their men at the Eston Steel Works to terminate all engagements. The company intend to reduce the wages, but they have not yet intimated what the reduction will be. Comparatively few hands are required in the production of steel rails, and it is expected that if the workmen refuse to accept the reduction of wages, the company will in the present state of the labour market be able to obtain a sufficient number of men to enable them to carry on the works.

Engineering and Shipbuilding.—Throughout the North there is less activity in shipbuilding and engineering. Although prices are extremely low orders cannot be had to keep the various works in full operation. Ironfounders continue to be fairly busy. In the Middlesbrough district pipe makers have a large quantity of work in hand.

The Coal and Coke Trades.—There is no alteration in the coal and coke trades. No marked improvement is expected until the iron trade is more active.

The Prospects of Trade.—The general opinion of people respecting the prospects of trade is that the worst of the depression has passed, and that the road to prosperity has actually been entered upon. There are persons, however, who fear that there will be many ups and downs before anything like prosperity is seen in Cleveland. It must be admitted when half the works in the district are idle, a considerable time will be required before orders can be obtained which will set the whole of the furnaces and finished works in operation.

NOTES FROM THE SOUTH-WEST.

The Tin-Plate Workers.—A meeting of tin-plate workers was held at Swansea on Saturday, when there were 200 delegates present, representing 41 works and 190 mills. A proposed reduction in wages was discussed, and it was finally resolved that, as the masters seemed to be disposed to meet the delegates amicably, they should do nothing in the matter until to-morrow (August 23).

Coedcae Colliery.—The Coedcae Colliery Company have succeeded in reaching the celebrated 9 ft. seam of steam coal at their new pit at Coedcae, Twm Cefn Prys, near Hafod, Rhonnda Valley, in addition to which the No. 3, the 2 ft. 9 in., and the 4 ft. 6 in. seams have been found to exist. The enormous wealth of coal now ascertained to be in the hands of this fortunate company will be seen from the fact that they have secured it over an area of 1300 acres.

Cardiff.—The general trade of the port for the past week has been fair, both in exports and imports. The demand for iron is better than for some time past, some large contracts having been booked for the United States. Others are also in the market. The demand for both kinds of coal is also improving; the returns, however, show a decrease in the quantity shipped foreignwise of 3977 tons as compared with the previous week. There was also a decrease of 1761 tons in the quantity of iron shipped last week, but a slight increase in the quantity of patent fuel exported.

Swansea.—An upward tendency has been observable in the tin market. There is no material increase in the value of spelter, but prices are well maintained. The copper market has slightly improved, but there has been no great advance in value. There is nothing fresh to be noted in the steel market.

Wages on the Taff Vale Railway.—On Saturday about twenty men, said to include the principal workmen in the west yard, gave in notices in consequence of an intention to reduce the wages of the men 5 per cent. At the Cathays the men have all accepted the reduction.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Suggested Tidal Canal.—A project of a most important character has been broached, having for its object the connecting of the midland coalfields with the sea by means of a huge canal which large steamers could traverse. As a central terminus Bawtry has been selected. It is proposed to provide two short lines of railway, one extending from Shireoaks to Bawtry, 10 miles, and the other from Rotherham to Bawtry, 14 miles; communication would thus be gained with the important lines. It is stated that the tidal navigation would be entirely free from the existence of any lock, and would consist of $15\frac{1}{2}$ miles of the River Trent from Whitton to Owston, which would have to be straightened, widened, and deepened, and $12\frac{3}{4}$ miles of new tidal and navigable cut or channel from Owston to Bawtry. As the district to be traversed is a low-lying fen, level, and below the level of high water, the excavation necessary would be reduced to a minimum. The present coal rate from South Yorkshire to London is 8s. 6d. per ton, but by the proposed navigation it would be 4s. per ton from Bawtry. We are informed that Mr. H. Fulton, is the engineer of the undertaking.

A Singular Speculation.—A circular of a novel character has been issued in Derbyshire. It proposes to "raffle" certain interests in a colliery near Chesterfield for the purpose of raising additional capital to enlarge the workings. The names of several private parties, and of the Chesterfield and Derbyshire Institute of Mining Engineers, have been most unwarrantably used in connexion with the affair. Mr. W. F. Howard, the secretary of the latter Association, repudiates the scheme, and considers the introduction of the name of the Institute in this manner a gross piece of impertinence.

Scarborough Water Supply.—The Corporation of Scarborough has resolved to increase its present water supply by extending the existing works rather than by drawing water from Jugger Howe, which was proposed and seriously intended.

Steel Rails.—We are informed that an order for 15,000 tons of steel rails for Canada has just been secured by Messrs. Brown, Bayley, and Dixon, of Sheffield. The contract has been carried in the face of determined American opposition.

FOREIGN AND COLONIAL NOTES.

Turning the Sahara into a Lake.—Foreign scientists are indulging in some speculation just now concerning the effects of making a great lake in the Desert of Sahara. At a recent meeting of the French Geographical Society at Paris, Dr. Cosson, a member of the Institute, combated the scheme with numerous arguments. He did not believe the climate of the interior of Africa would be changed by the artificial sea. Its shores would be as arid as those of the Mediterranean in Tripoli; but if the climate should change, the date crop, which is the principal support of the natives, would be ruined. The routes of the caravans from Tunis and Algiers to the interior would also be destroyed, and the whole inland trade deranged. Dr. Cosson also predicted that the pressure of the mass of water would produce perturbations in the subterranean currents which feed the artesian wells in the oases, and might cause them to fail, and thus entail the loss of hundreds of thousands of palm trees. His views as to the climatic influence of a Saharan Sea were opposed by other members of the society.

American Machinery in England.—Messrs. Totten and Co., of Pittsburgh, have just received their fifth recent order from England for machinery. The chief demand for the English market is for nail machines for cutting both iron and steel, and for hollow chilled rolls. This firm have made more nail machines for England than any other American maker. They are also the only manufacturers under United States patents of the hollow chilled rolls.

Geelong.—Sir John Coode has submitted alternative designs for improving the entrance to the inner harbour. No. 1 is an entirely new cut, which would cost 64,470*l.*, and the other (No. 2) contemplates the retention of the line of the present South Channel, with an increase of its capacity, the estimated cost being 36,730*l.* Sir John adds, "Whether the saving of distance and general convenience by the adoption of design No. 1 would be of such importance as to warrant the additional outlay, is a matter upon which the nautical advisers of the Victorian Government will be better able to pronounce an opinion than I can be."

A New Russian Shell.—Naval circles in St. Petersburg have been much occupied with a discovery intended to supersede torpedo boats. A chemist in the Russian capital has invented a bombshell charged with dynamite which can be projected a distance of 200 yards, and explodes from the shock either against the vessel or the water, and produces terribly destructive results. The use of these shells is said to be less dangerous than torpedoes and much more economical.

Iron Making in Georgia.—The Atlanta Georgia Rolling Mill has, since last November, been under the management of Mr. Grant Wilkins, of the Atlanta Bridge Works (Wilkins, Post, and Co.), and it is now manufacturing rails, fishplates, merchant bars, and bridge iron. The mill employs 500 men, and is running full double turn, having orders on hand for the Houston and Texas Central Railway, the Hartwell Railroad, the Macon and Brunswick Railroad, the Cheraw and Chester Railroad, the Mobile and Girard Railroad, the Charlotte, Columbia, and Augusta Railroad, and the Atlantic and West Point Railroad, besides three other roads. The orders for bar iron are in excess of the productive capacity of the company. Their present orders will keep the works busy until November.

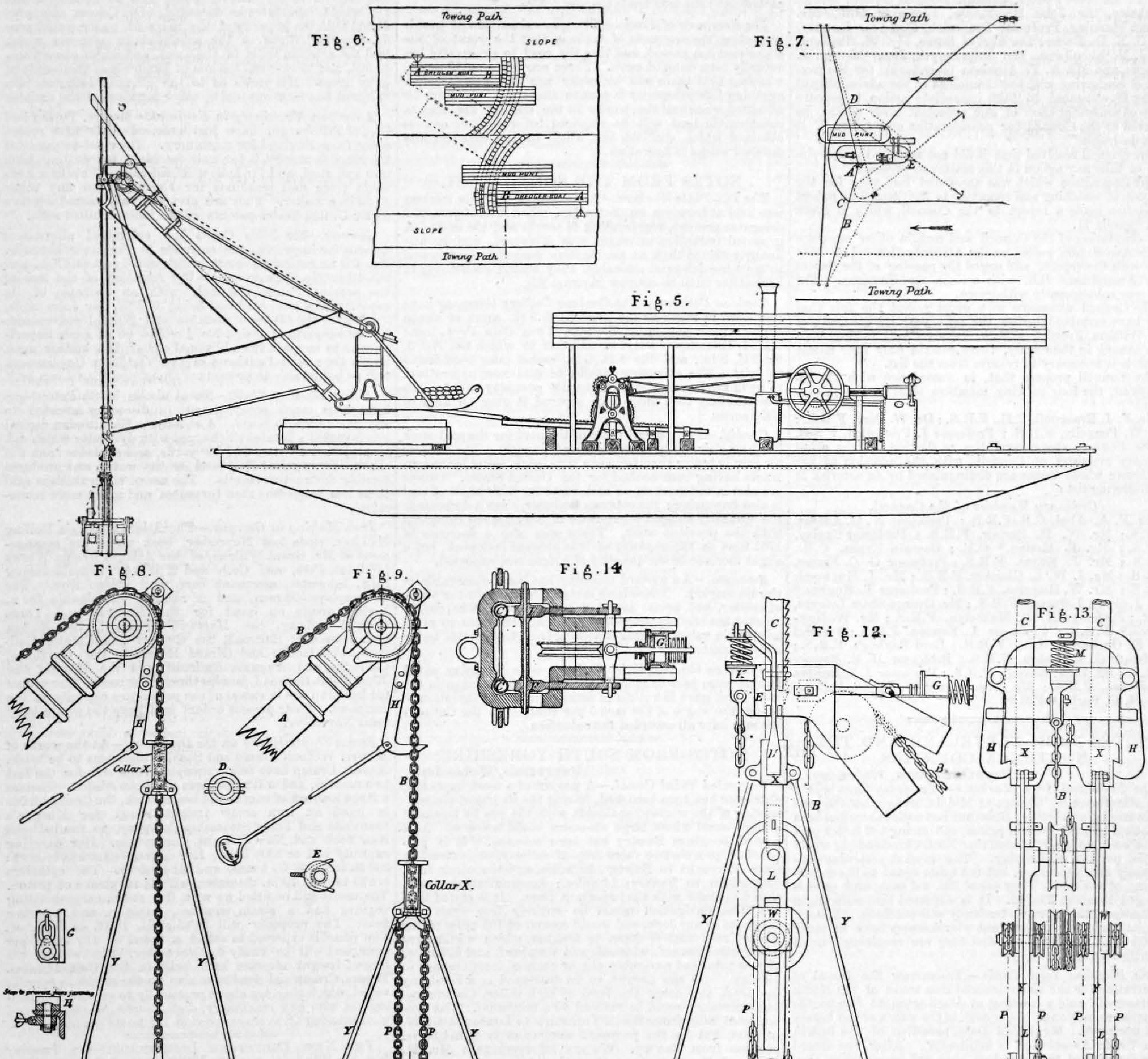
Steam Shipbuilding on the Delaware.—At the works of Messrs. William Cramp and Sons, trade seems to be brisk. Messrs. Cramp have been employing 1000 men for the last two months, and will need them until the winter. Besides a large amount of engine and boiler work, the Cramps have in hand an iron screw freight vessel for Morgan's Louisiana and Texas Steamship Company, to run between New York and New Orleans, for cotton. Her carrying capacity will be 8000 bales. Her dimensions are as follows: 340 ft. long, 42 ft. beam, and 31 ft. deep. The cylinders are 35 in. and 70 in. diameter, with $4\frac{1}{2}$ ft. stroke of piston. The vessel will be fitted up with five steam cargo-hoisting engines and a steam windlass, capstan, and steering gear. The propeller will be of steel, 16 ft. in diameter. The vessel is expected to attain a speed of $11\frac{1}{2}$ knots per hour, and will be ready by November. She will be the largest freight steamer ever built in the United States. Messrs. Cramp and Sons have also on the stocks a Spanish vessel, which they are about practically to rebuild, furnishing her with new machinery, deck, screw, masts, &c., and guaranteeing an average speed of $12\frac{1}{2}$ knots per hour.

THE NEW EDDYSTONE LIGHTHOUSE.—On Tuesday last, the 19th inst., the foundation stone of the new Eddystone Lighthouse was laid by the Duke of Edinburgh as head of the Trinity Board; the Prince of Wales being present. The circumstances which have led to the commencement of a new lighthouse destined ultimately to replace the famous structure of Smeaton were fully detailed in a paper read by Mr. James N. Douglass, the engineer of the Trinity House, before the British Association in 1877. This paper will be found on page 217 of our twenty-fourth volume.

THE CHROMOGRAPH.—Under the name of the "chromograph" the Chromograph Company, of Farringdon-street, have lately introduced a very simple and convenient apparatus for reproducing manuscripts, plans, &c. The arrangement consists of a shallow zinc box containing a white composition similar in feeling to that used for the inking rollers of printing machines. The writing which it is desired to reproduce is written in the ordinary way on any paper, but with a special ink. When thus written it is laid writing downwards on the slab of composition above mentioned, and the hand is lightly passed over it. After being allowed to remain about a minute it is removed, when the slab will be found to have received a transfer of the writing. From the slab thus prepared some forty to fifty copies can be printed simply by laying any ordinary paper on the slab, smoothing it down lightly by the hand, and allowing it to remain two or three seconds. No re-preparation of the slab is required, and when it is done with the slab is simply cleaned off by washing. The arrangement is altogether an extremely handy one, and will no doubt come extensively into use. It can of course be equally applied to the reproduction of tracings if these are inked in with the special ink.

THE FOURACRES EXCAVATOR.

(For Description, see opposite Page.)



TECHNOLOGICAL EXAMINATIONS.—The results of the first technological examinations held by the newly-formed City Institute for Promoting Technical Education have just been published. These examinations were established by the Society of Arts in 1873, and at the beginning of the present year they were transferred to the Institute. The number of candidates examined was 202, of whom 151 satisfied the examiners in technology. These candidates were examined in seven different subjects: Cotton manufacture, manufacture of steel, &c., gas manufacture, wool dyeing, alkali manufacture, telegraphy, and qualitative blowpipe analysis. Besides these subjects there were nine other subjects in which it was announced that examinations would be held, viz.: Paper manufacture, silk manufacture, carriage building, pottery and porcelain, glass manufacture, cloth manufacture, silk dyeing, calico bleaching, &c., and photography. In these no candidates presented themselves. These candidates were examined at twenty-three different centres in various parts of the kingdom, including Oldham, Crewe, Manchester, Dublin, Liverpool, Preston, St. Helen's, Halifax, Cardiff, Bolton, Huddersfield, Blackburn, Redruth, and London. In the programme of examinations for next year, which will shortly be issued, many important alterations have been made, and it is expected that the offer of payments to teachers of successful candidates will attract many more candidates than have yet appeared.

STEAM DREDGING IN INDIA.

*On the Construction and Working of a Vertical Action Steam Dredger in India.**

By MR. R. B. BUCKLEY, of the Indian Public Works Department.

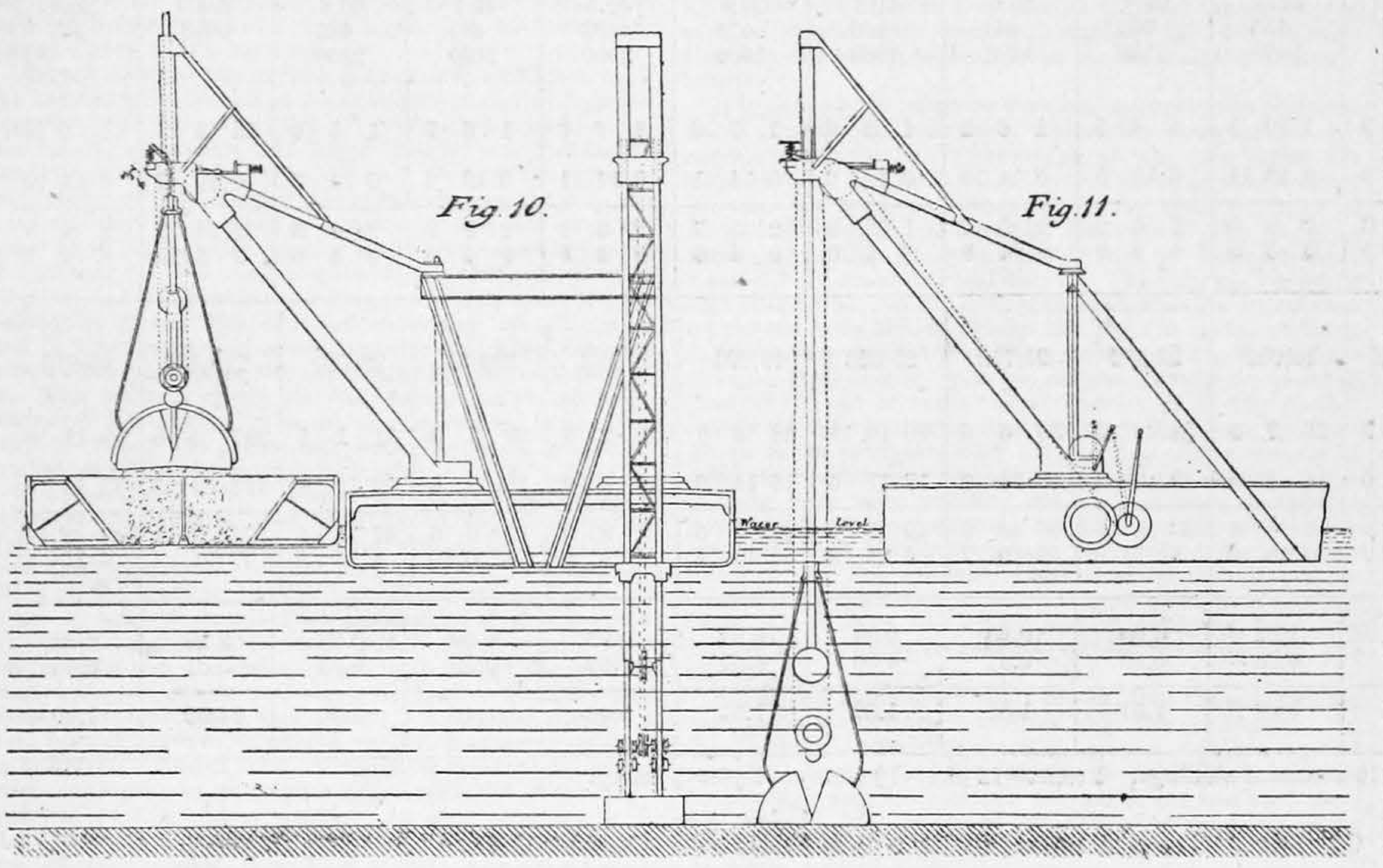
THE dredger which this paper proposes to describe is one recently constructed by Mr. Charles Fouracres, engineer in the service of the Government of Bengal. The dredger was first put into regular work in the Patna Canal in Bengal under the direction of the author, who from time to time personally inspected the working of the machine, and verified the observations on which the facts given in this paper are based. Another dredger on the same principle is also working in the Arrah Canal in Shahabad, and one or two more are in course of construction, one for the Midnapore Canal near Calcutta, for the purpose of clearing out the silt which annually blocks the heads of most Indian canals.

Description.—The general arrangement of the dredger, as it has hitherto been made, is shown in Fig. 5 (page 156). The peculiarity consists in the machinery, and in the arrangement of the parts which are there seen suspended from the head of the jib. The arrangement for working this machinery by means of a portable engine, crab-winch, and crane, as shown, is somewhat primitive, and would not, of course, be adhered to in large dredgers; this arrangement was adopted simply because those machines were the best means available, in the canal workshops, for fitting up the dredger. The engine used was one of six horse power nominal; it drove the 1½-ton crab-winch direct by two straps, one of which was crossed and one straight; so that the man at the winch was able, with great facility, to wind up or unwind the chain, which was attached at one end to the drum of the winch, and at the other to the dredging apparatus. Six mud-punts, with flush decks and removable sides, accompanied the dredger. Each punt was capable of carrying only about eighteen yards of material. It was found that these six punts were just sufficient to keep the dredger in full work when the lead did not exceed three-quarters of a mile. All the mud was discharged from the punts into the river by labourers throwing it overboard; the material in each punt being levelled off and measured before it was discharged.

The crane, to which the dredging scoops were hung, was made to revolve on its vertical axis by a horizontal rack, which could be put into gear with a pinion on the outer extremity of the main shaft of the winch, by means of a pedal. This pedal the man driving the winch pressed with his foot whenever he wished to cause the dredging bucket to revolve, whether in order to come over the mud-punt and deposit its load, or to return to the centre of the dredger. This arrangement, by which three machines—the engine, the winch, and the crane—were made to do the work of raising and lowering the dredging scoops, was rather an expensive one, as each machine required an attendant; whereas had a steam crane, with rapid reversing and revolving gear, been available, one man might have done the work of these three.

The dredging apparatus, as shown in Figs. 1, 2, 3, and 4, page 153, consists of two segmental scoops M, hinged on a crosshead which is firmly welded on to a wrought-iron spear L; this latter being attached by a key to a light wooden spear C. The scoops, when closed, form a bucket of the form of about half a cylinder. Two metal collars, W and X, slide freely on the iron and wooden spears respectively; the upper one is connected to the scoops by the light iron rods Y Y, and the lower one by two chains P P. One end of each of these chains is connected to the lower collar, and the other, after passing through one of the sheaves Q Q, is attached to the end of one of the semi-circular angle-irons O O; the chain on the right hand of the spear being attached to the angle-iron which is rivetted to the right scoop, and the chain on the left hand of the spear to the angle-iron which is rivetted to the left scoop. These chains then cross each other, as it were, around the sheaves Q Q; and since the semi-circular angle-irons also cross one another at the same point, the chains, when placed in tension, tend to close the scoops upon one another into the position show in Figs. 2 and 3. The angle-iron which is rivetted to the one scoop wraps itself round the other scoop, when the bucket is opened into the position shown in Figs. 1 and 4. Both of these angle-irons are carefully chipped and filed to a segment of a true circle on their upper edges; these edges bear against two friction rollers which revolve on the same pin which carries the sheaves Q, and which tend to preserve the angle-irons in their proper shape.

The sliding collar W has a sheave within it around which the main lifting chain B is rove. When working in soft soil, the chain B is attached directly to the collar W; but in hard soil power is gained by passing the chain through the sheave, and fastening the end of it to the spear, as shown in Figs. 3 and 4. This main chain is worked over the head of the crane, as shown in Figs. 1 and 2. Stops R and S are provided to prevent the scoops over-running themselves, and thus getting jammed.



One of the main features of the dredger is the float catch T; this catch is hinged to the top of one of the scoops, and, when the scoops are open, as in Figs. 1 and 4, it hooks on to a lug on the top of the other scoop. It thus ties the two scoops together at the top, and prevents them from closing as the catch remains in that position.

The hooks H, which are attached to the jib-head, are so counterbalanced by the weight K that they fall forward into the position shown in Figs. 1 and 2, when the rope attached to them is slack. These hooks have at their lower extremities sloping faces, such that, when the clutch collar X rises up to them, the projecting arms of this collar push back the hooks, and rise past them; when the arms are above the hooks, the latter fall forward and support the arms, so as to prevent the collar from returning. When in this position the main lifting chain may be lowered, and the whole dredging apparatus remains hanging to the jib-head on the hooks H. The entire weight being thus thrown on the collar X, which is attached to the scoops by the rods Y, the scoops are drawn open into the position shown in Fig. 1.

The lever G is centred in the jib-head, and has attached to it a lug or cam, which bears on a very shallow rack fixed to the spear C; on pulling the rope attached to the lever, this cam jams the spear in the guide E so that it cannot rise.

N N are stiffening bars, and V V are leather valves, which allow water to escape if the bucket is not filled with mud, but which are closed by and retain any solid matter the scoops may cut into.

The action of the dredge is as follows:

The main lifting chain B is attached to a winding engine, or to a crab-winch worked by a portable engine, or to any machine such that the man who regulates the machinery can wind up the chain, or unwind it, or hold it stationary at any moment he pleases. The dredge is first lowered into the water in the position shown in Fig. 1, by unwinding the main chain. While it is being lowered this chain is of course tight, as it bears the entire weight of all the movable parts of the dredger. The strain on the main chain tends to draw the travelling collar W upwards on the spear L; this tightens the closing chains P P, the strain on which, acting on the semi-circular angle-irons O O tends to close the scoops of the bucket. The catch T, however, holds the two scoops together at the top, and prevents them from closing. In this manner the bucket descends, the wooden spear C sliding freely down in the guides D and E.

When the bucket reaches the bottom, which it generally does with somewhat of a blow if the engine be run quickly, the scoops rest on the surface of the mud; they open slightly, and the strain is taken off the catch T, which immediately rises out of gear by means of the flotation of the ball attached to it: thus the scoops are released and free to close. The stops S prevent the scoops from opening more than is just sufficient to release the catch T. Immediately the scoops reach the bottom, the attendant reverses the machinery and winds up the main lifting chain; at the same moment the lever G is pulled over by the rope attached to it and jams the spear tightly in the guide E. As the main lifting chain ascends, it draws the collar W upwards on the spear L, and the collar draws up the chains P, which cause the semi-circular angle-irons O to press the scoops M into the material on which they were resting. The spear is meanwhile held fast in the jib-head by the lever, and cannot rise; thus the scoops are compelled to bite into the soil. But if any very hard matter is met with, the pressure on the spear causes the cam to jump out of the shallow rack, and no damage is done. As soon as the bucket is closed, which can be easily known by watching the point to which the collar X descends on the spear, the lever is released, and the whole apparatus rises to the surface by the continued action of the main lifting chain.

When the bucket rises to the surface of the water, the crane A is revolved until the bucket hangs over the mud-punt, which is alongside the dredger. As the clutch collar X rises the projecting arms push back the hooks, which immediately afterwards fall back into position underneath the arms. As soon as the attendant sees that the hooks have thus caught the arms of the collar, he reverses the winding of the chain; the rods Y then take the whole weight of the apparatus, the spear and heavier parts descend, and the scoops M are pulled open, partly by the weight of the material they themselves contain, and partly by the weight of the descending parts, the whole of which presses upon the crosshead of the spear L, and thus tends to open the scoops. When the scoops are wide open the stops R bear on the spear L, and the catch T falls automatically into position, catching the other scoop. The dredger is now ready for another bite. The slack of the main lifting chain is taken up, and the weight of the apparatus is taken off the hooks H sufficiently to enable them to clear the arms of the clutch-collar. The hooks are then drawn back, the crane revolved, and the apparatus run down to the bottom again as before.

The engine—or winch worked by the engine—has to be reversed three times during each lift. Firstly, after lifting the clutch-collar from the hooks, it has to be reversed to lower the bucket; secondly, when the bucket reaches the bottom, it has to be reversed to lift it; and, thirdly, when the bucket is over the mud-punt it has to be reversed to empty it. In the dredgers which have already been constructed, the necessarily rapid reversal of the motion of the main chain has been effected by sliding forks on the crab, which move direct and crossed straps alternately on to the tight pulley. It requires some practice to work the dredger quickly, but an intelligent labourer soon learns to do the work.

Figs. 8 and 9, page 156, show a modification of the dredging scoops, which is applicable for cutting very soft silt or light sand. Similar parts are marked with the same letters as apply to the previous description. In this arrangement the spear is dispensed with, and the sliding collar X works on the lifting chain itself. The working of this arrangement is almost exactly similar to that of the one already described.

Results of Working.—The dredger has been at work for about eight months at the head of the Patna Canal. The canal at this point has 180 ft. base, 7 ft. general depth, and side slopes 1½ to 1. There were 40,740 cubic yards of silt, partly sand and partly black alluvial deposit, in the first half mile of this canal. In some places there was as much as 4 ft. of silt, but in others only 1½ ft. or 2 ft. The dredger of course worked to the greatest advantage in the deepest silt, as less manipulation of the boat itself was necessary. The depth to which the silt was dredged below the surface varied from 3 ft. to 7 ft.

The dredger tried was an iron one of the following dimensions:

	ft.	in.
Length	50	0
Breadth	15	0
Depth	4	0
Maximum draught of water	1	9
Nominal horse power	6	
Capacity of bucket	16 cub. ft.	
Greatest depth to which the dredger was to cut	8	0

The dredger was first started with the regulating apparatus designed by Mr. Fouracres. The dredger was secured in position, as shown in Fig. 6, page 156, by a T-strut, the base of which was fastened to the bank by two pins. The further end of the strut was fitted with an eye, which worked on a pin attached to the stern of the dredger at A. This strut fixed the point A, and the dredger was only able to revolve about that point as a centre. To the other end of the dredger a piece of quartering was attached, working at B on another pivot similar to the one at A. This quartering was of sufficient length to allow the bow of the dredger to be moved a few feet beyond the centre of the canal. The quartering was marked into divisions of 4 ft. each, which was the width of the bite of the bucket. After the bucket had taken its first bite the boat was shoved off the distance of one of these divisions of 4 ft. by men on the bank working a small twofold tackle. Thus, each time the bucket was lifted, the dredger was moved out the distance of 4 ft., and the bow of the dredger was compelled to work in the arc of a circle. If it was found that one bite of the scoops was not sufficient to clear out the canal to the requisite depth, two or three bites were taken at the same spot, or the dredger was run a second or third time over the same arc. When it was necessary to move the dredger forward to work on a new arc, the T-strut at A was shifted about 2 ft. 6 in. along the bank, that being the width of

* Paper read at the Glasgow Meeting of the Institution of Mechanical Engineers.

TABLE I.—FOURACRES' DREDGER. ABSTRACT OF WEEKLY AVERAGES AND TOTALS OF WORKING.

Items.		1878. 2 Nov.	9 Nov.	16 Nov.	23 Nov.	30 Nov.	7 Dec.	14 Dec.	21 Dec.	28 Dec.	1879. 4 Jan.	Total.	Average.
Weekly averages.													
Quantity lifted by bucket each time	cub. ft.	12.0	12.4	12.2	12.0	11.8	11.2	11.6	11.9	11.8	11.4	118.3	11.8
Number of bucketfuls per hour		42.5	40.1	42.1	47.6	47.7	49.0	...	44.4	50.5	...	363.9	45.5
Daily time of dredger working	hrs. mins.	5 31	6 36	6 27	6 39	6 20	7 27	...	6 41	6 53	...	52 34	6 34
Daily time of men employed	hrs. mins.	...	9 17	8 32	7 58	8 33	9 6	...	8 54	8 25	...	60 45	8 40
Daily quantity excavated	cub. ft.	3210	3135	3604	3762	3625	4172	3839	3622	3991	3953	36,913	3691
Time of loading each puntful	mins.	51	53	53	49	50	50	...	53	49	...	408	51
Number of bucketfuls in punt		39.3	36.1	37.1	39.4	39.6	41.3	39.6	40.5	41.1	40.6	394.6	39.4
Quantity in loaded punt	cub. ft.	467	426	454	465	468	466	475	483	486	483	4673	467
Lead of punt	ft.	1200	1300	1400	1500	1600	1800	1900	2000	2100	2200		
Cost per 1000 cubic feet :*													
Dredging and delivering into punt ...	r. a. p.	1 4 6	1 9 3	1 10 1	1 8 5	1 6 2	1 3 8	1 7 6	1 7 0	1 6 7	1 5 0	14 4 2	1 6 10
Leading punts and discharging into river ...	r. a. p.	1 0 2	1 2 0	0 13 11	0 13 9	0 14 10	0 12 0	0 14 1	0 12 1	0 12 2	0 11 3	8 10 3	0 13 10
Total per 1000 cubic feet	r. a. p.	2 4 8	2 11 3	2 8 0	2 6 2	2 5 0	1 15 8	2 5 7	2 3 1	2 2 9	2 0 3	22 14 5	2 4 8
	£ s. d.	0 4 7	0 5 5	0 5 0	0 4 9	0 4 8	0 4 0	0 4 8	0 4 5	0 4 4	0 4 0	2 5 10	0 4 7
Weekly total.													
Weekly quantity excavated... ...	cub. ft.	22,474	15,677	18,022	22,572	21,752	25,033	19,194	21,732	19,956	23,720	210,132	21,013
Weekly expenditure* ...													
Dredging and delivering into punt ...	r. a. p.	28 12 1	24 11 9	29 7 9	34 10 3	30 6 6	30 10 11	28 3 0	31 2 0	28 3 0	31 1 5	297 4 8	29 11 8
Leading punts and discharging into river ...	r. a. p.	22 11 0	17 10 0	15 8 6	19 3 3	19 14 0	18 11 6	16 14 6	16 6 0	15 3 6	16 12 0	178 14 3	17 14 3
Total weekly expenditure	r. a. p.	51 7 1	42 5 9	45 0 3	53 13 6	50 4 6	49 6 5	45 1 6	47 8 0	43 6 6	47 13 5	476 2 11	47 9 11
	£ s. d.	5 2 11	4 4 9	4 10 0	5 7 8	5 0 7	4 18 9	4 10 2	4 15 0	4 6 10	4 15 8	47 12 4	4 15 3
Average cost per cubic yard. Dredging ...	pence	0.84	1.03	1.06	0.99	0.90	0.80	0.94	0.93	0.90	0.86	9.25	0.93
Discharging	,,	0.65	0.73	0.56	0.55	0.61	0.50	0.57	0.50	0.50	0.44	5.61	0.56
Total ...	,,	1.49	1.76	1.62	1.54	1.51	1.30	1.51	1.43	1.40	1.30	14.86	1.49

* 1 rupee=16 annas=2 shillings. 1 anna=12 pies=$1\frac{1}{2}$ penny. 1 pie=$\frac{1}{8}$ penny.

TABLE II.—COST OF DREDGING BY DIFFERENT MACHINES IN BENGAL.

Items.		A.	B.	C. 1875-6.	C. 1876-7.	C. 1877-8.	D. Victoria.	D. Princess Louise.	E. 1874-5.	E. 1875-6.	E. 1876-7.	E. 1877-8.	F. Fouracres'.
Cost of dredger	£	4200	...	5358	5358	5358	...	2000	...	...	...	...	800
Nominal horse power ...	HP.	24	6	15	15	15	...	10	...	...	...	...	6
Greatest depth to which dredger will excavate ...	ft.	5	5	10	10	10	...	18	...	...	...	...	8
Total period of working ...	days	84	187	...	...	...	...	...	214	190	192	221	125
Total quantity excavated ...	cub. yds.	13,333	7838	40,639	10,370	15,896	...	...	63,579	97,611	91,537	113,926	16,838
Working cost.		Rupees.*	Rupees.	Rupees.	Rupees.	Rupees.	Rupees.	Rupees.	Rupees.	Rupees.	Rupees.	Rupees.	Rupees.
Dredging alone		...	...	7,083	2957	3,444	...	...	...	...	...	...	691
Dredging and discharging ...		1932	1807	11,807	4851	4,880	...	...	28,960	27,462	25,536	28,775	1063
Dredging, discharging, and repairs		...	...	14,198	8351	5,937	...	...	34,934	35,401	37,175	40,858	1202
Dredging, discharging, and repairs, and 10 p. c. int., &c.		...	...	19,556	13,709	11,295	...	...	...	...	...	...	1535
Average cost per cubic yard		Pence.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.	Pence.
Dredging alone		...	...	4.18	6.84	5.19	2.62	3.72	...	...	...	...	0.98
,, and discharging ...		3.47	5.53	6.97	11.22	7.36	6.42	7.60	10.92	6.75	6.69	6.04	1.50
,, discharging and repairs ...		...	...	8.38	19.32	8.96	...	...	13.18	8.70	9.74	8.60	1.71
,, ,, repairs, and 10 per cent. interest, &c.		...	...	11.54	31.72	17.00	...	...	...	...	...	...	2.18

* 1 rupee=2 shillings.

PARTICULARS OF DREDGERS INCLUDED IN TABLE II.

A. Ladder and bucket steam dredger, 94 ft. long, $15\frac{1}{2}$ ft. beam, $6\frac{1}{2}$ ft., draught. Sixteen buckets of 4 cubic feet each.

B. Single scoop steam dredger, 50 ft. long, 13 ft. beam, $6\frac{3}{4}$ ft. draught. Scoop working on a vertically oscillating arm.

(A. and B.) These dredgers were employed in clearing silt and sand from the heads of the High Level and Kendraparab Canals. The lead of the punts was not more than $\frac{3}{4}$ mile.

C. Ladder and bucket steam dredger, 120 ft. long, 18 ft. beam, 6 ft. draught. This dredger worked part of its time in tidal water, and was therefore hindered. It never actually did 120 cubic yards in a day, and generally excavated to about 7 ft. depth below water level.

D. Ladder and bucket steam dredgers. These work pretty constantly in the Calcutta circular canals. The cost of repairs is not stated by the engineer.

E. Ladder and bucket steam dredger "Octopus." This belongs to the Calcutta Port Trust, and has been chiefly employed in clearing out silt near the jetties. The lead of the discharging hopper-barges was short.

F. Fouracres' steam dredger, with vertical-acting bucket, 50 ft. long, 15 ft. beam, 4 ft. draught. This dredger has been working for five months in the Patna Canal. The lead of the punts averaged about 500 yards.

the bucket used; and the dredger was thus set to cut another arc parallel to the last.

This arrangement, though an excellent one when working near a bank, or in a narrow canal where there is much traffic, was not found suitable for dredging a channel of 50 ft. width down the centre of the canal, which was the work required to be done. Indeed it seems doubtful whether a well-arranged system of anchors would not always be more convenient for working this dredger. The arrangement shown in Fig. 7, page 156, was therefore adopted. A small gipsy winch A was fitted on two uprights at the edge of the dredger. A small capstan would have been more suitable, since the regulating chain B would not have jammed on a capstan as it did sometimes on the winch. By turning the winch A, it was easy to regulate the movements of the dredger, causing it to oscillate in the arc C D. Two anchors, attached by $\frac{3}{8}$-in. chains to a bollard on the stern of the dredger, kept the point E very nearly stationary, the action of the current tending of course to keep the anchor chains tight. Occasionally, as the stream varied, the dredger would perhaps float slightly out of its proper course, in which case the bucket might come up very nearly empty; but this did not occur very frequently. When the dredger had worked up to the point D, the anchor chains were slackened and the dredger moved forward about 2 ft. 6 in., the width of the bucket; the man regulating the dredger then reversed the winding on the winch A, and gradually brought the dredger back to the point C, and so on continually. Occasionally, when the anchor chains became long and the dredger was perhaps somewhat swept off her course by the action of the current, or when the anchor chains had been slackened by more than the proper amount, a ridge of silt would be left which the dredger had to be brought back to cut. But generally speaking the channel was cut very cleanly.

Some difficulty was at first found in managing the mud-punt in the stream, the silt generally came up so hard and dry that it would not spread itself over the deck, and it was necessary to move the punt frequently, so that the silt might be uniformly deposited. An arrangement of hooks on the punts and small bollards on the dredger was, therefore, adopted; by this the labourers were able to draw the punt by hand into any required position, and fasten it to the bollards on the dredger by small pieces of rope. Two pairs of bullocks towed the full punts to the river, and brought back the empty ones.

The silt dredged varied from pure sand to soft black mud; the heavier particles (*i.e.*, the sand) were of course deposited near the head sluice, and the silt gradually became less and less sandy, and more and more muddy, the further the dredger worked from the sluices. One of the greatest advantages of this dredger is that it brings up the silt quite hard and dry. The greater portion of the silt excavated could have been at once carried on coolies' heads in baskets if necessary. It is also remarkable how little the dredger stirs up the mud when working; it works most cleanly, taking its proper bite without disturbing the silt near it, and in this respect is much superior to other dredgers, which often plough up the silt into a thin slush as they lift it. The leather valves on the scoops acted capitally; whenever the bucket came up partly empty, most of the surplus water had fallen out into the canal, before the bucket was turned over the mud-punt.

It was noticed that in pure sand the scoops frequently failed to cut properly, and that the bucket came up only half full. This was due to the fact that at first the shallow rack arrangement, which has been described, had not been fitted on the dredger, but the lever G only pressed upon the spear by a simple cam. The consequence of this was that when cutting into pure sand, which is of course much harder than silt, the spear slipped up in the guides, and the bucket did not get its full bite; the shallow rack arrangement, however, cured this defect. When the dredger is used for cutting into very hard soil Mr. Fouracres proposes to make the scoops of somewhat greater radius, but forming only one-sixth or one-eighth of a cylinder instead of a quarter, as they do at present; he also proposes to fix steel teeth to the edge of the bucket, so as to catch the ground more readily. The effect of this arrangement would be that the scoops would drag more along the ground, and not cut into it so deeply as they do at present.

It will be manifest that this dredger possesses considerable advantages when working where there are waves or a swell. For when the scoops are resting on the bed of the river or harbour to be dredged, they will cut into any soft soil without jamming, as the buckets of an ordinary dredger are apt to do. It will be seen that the lever G only holds the spear down, so as to stop its rising; if the dredger rose on a wave, the lever would not lift the spear, which would slip down in the guides; and if the dredger fell on a wave, the lever would give way when the pressure became too great for it to hold. The dredger is also very handy for working in corners and near wharves or piers, where an ordinary dredger cannot sometimes find room to work. Again the author believes that in the old form of dredger the buckets rarely bring up on the average more than half the quantity which they could contain; this is chiefly due to the fact that it is almost impossible to regulate the forward motion of the dredger so exactly that the cut taken by each bucket is just sufficient to fill it. If the feed is too great, the front buckets churn up the extra mud which they cut into slush, and this is brought up by the following buckets. It is very probable too that if the buckets come up with a good load of heavy sticky mud, it will adhere to the bucket, and the whole will not fall out into the shoot. These difficulties are entirely overcome by the new dredger, which can never cut more than it requires, and which must necessarily leave the whole of its contents in the mud-punt, for it opens entirely and the contents must drop out. When working in the most sticky stuff the bucket entirely clears itself, with the exception of some small lumps on the edge and corners of the scoops.

This dredger is also peculiarly suitable for working in tidal waters, where the varying depth causes trouble in the ordinary ladder dredger, necessitating the constant alteration of the ladder. Moreover, as this gradually gets more horizontal the ordinary dredger works at a greater and greater disadvantage, as more mud drops from the buckets on their way to the shoot. In Fouracres' dredger the efficiency increases as the tide falls; for the work done and friction on the parts is directly proportional to the height of lift. The dredger will work to advantage as long as it will float.

During the first ten weeks of the working of the dredger in the Patna Canal, an accurate account was kept, showing the engine hours, number of buckets lifted, &c. This account is tabulated in Table I. After those ten weeks only sufficient information was taken to give the cost per yard excavated. In Table I. the cost of repairs is not given, partly because the accounts were not ready at the time the Table was made out, and partly because the dredger was quite new, and needed of course but little repair during the first ten weeks it was at work. The results of the ten weeks' trial give:

Maximum quantity excavated in a day of $9\frac{1}{2}$ hours ...	172 cubic yards
Average quantity per day of $8\frac{3}{4}$ hours	137 ,,
Maximum quantity per nominal horse power per hour ...	3.82 yards
Average quantity per nominal horse power per hour ...	3.51 ,,
Average number of buckets lifted per engine hour ...	$45\frac{1}{2}$
Average quantity lifted each lift (full bucket being 16 cubic feet)	11.8 cubic feet

The amount lifted per bucket is disappointing; for, when working in soft soil or in a mixture of light marl and sand, the bucket frequently came up containing 18 or 20 cubic feet, the material being heaped up above the crosshead. The comparatively small average per bucket must be attributed partly to the want of the rack arrangement which has since been introduced, and partly to the fact that, when cutting only a shallow layer of silt, it is not possible always to fill the bucket, as the material is not there to fill it. It will be seen that though the lead increased, the cost of discharging decreased during the ten weeks; this was due to improvements in the discharging arrangements.

It is not easy to compare with real accuracy the performances of different machines, unless the observations are conducted by the same person, or at any rate under the same system, and unless the circumstances are thoroughly known. Through the kindness of the chief engineer of Bengal the author has obtained statistics of the performances of various dredgers now in use in Bengal; these statistics are embodied in Table II. The information is the best obtainable, but the author must express his regret that he has not been able to obtain the facts in sufficient detail to enable him to fill up all the columns. This Table gives the cost of dredging by seven different dredgers, working generally in silt or sandy river deposits of a very similar nature to the material excavated by the new dredger. These seven dredgers were all working under somewhat different conditions, and cutting to different depths; some of them were only working for a short time during the year, and some were working in tidal waters, where they were placed at the disadvantage of being hindered at low tide; so that the columns which contain the charges for interest and depreciation are not really comparable; but those which show the actual cost of dredging, lead, and repairs are as fairly comparable as the circumstances will allow.

From this Table it is clearly evident that the new dredger works at a much lower cost than any other in Bengal. In the Table is shown the working of this dredger for five months. During that time she worked 125 days, was idle 23 Sundays and 1 Christmas Day, and was laid up 5 days for repairs. She executed on the average 134.7 cubic yards per day at a cost of 2.18 pence per yard, including dredging, lead, repairs, and interest and depreciation on prime cost.

One of the greatest advantages which the dredger offers is the small cost of repairs. It will be noticed that during the five months she was working the cost of repairs was only 139 rupees (13*l.* 18*s.*). Supposing that this figure was doubled, or even trebled, in an older dredger, the cost of the work done would still be very low. It has been found that there is very little wear except on the cutting edges of the bucket scoops. These get very blunt when working in sharp sand. The first bucket was made of iron and wore away very quickly. The later ones with steel edges have worked much better. As one bucket can be detached from the spear and another substituted in about twenty minutes, ordinary repairs do not delay the working of this dredger, whereas in the ladder and bucket dredger the removal and renewal of the links and pins is a troublesome and lengthy business. Again, the wear of the links in the latter class of dredgers interferes with their efficiency; for it sometimes becomes necessary to lift the ladder slightly, as the chain of buckets sag, otherwise they are apt to foul the edge of the well. In the new dredger this difficulty can never occur, and there is nothing to interfere with the depth to which the dredger will cut, except the length of the spear and main chain.

The comparison of the cost of the working of the new dredger with the cost of others working in England is rendered less satisfactory than the comparison just made by the fact that the value of labour and materials varies in the two countries. The establishment employed on the dredger in India was more numerous than would be required in England, but the pay of the men was less. Again, coals cost in India about 30*s.* to 40*s.* a ton, while on the Clyde and Tees they cost from 5*s.* to 10*s.* only. If it is supposed that the cost of labour here would be double or treble what it is in India, the cost of the work done would still compare favourably with dredgers working here; and it must not be forgotten that it is comparatively much more expensive, as far as establishment is concerned, to work a dredger of six horse power than one of five or six times the size; also that in a dredger properly constructed with a winding engine the establishment would be still further reduced. There were in India no less than fourteen hands employed on the dredger.

The following is the cost of dredging on the Clyde, as given in Mr. Deas's paper read before the Institution of Civil Engineers in 1873 (Proceedings, vol. xxxvi. p. 124):

Cost of dredging only	1.31d. per cub. yd.
,, ,, and repairs ...	2.53d. ,, ,,
,, ,, repairs, and 10 per cent. interest and depreciation on prime cost	3.85d. ,, ,,
Quantity dredged per nominal horse power per hour... ...	1.65 cubic yards

Mr. John Fowler has kindly informed the author that the following is the cost of dredging on the Tees, allowing 10 per cent. interest and depreciation, which however he considers too high:

Cost of dredging only	1.35d. per cub. yd.
,, ,, and repairs ...	2.09d. ,, ,,
,, ,, repairs, and 10 per cent. interest and depreciation on prime cost	3.17d. ,, ,,
Quantity dredged per nominal horse power per hour... ...	1.59 cubic yards

Design for large Dredger.—Mr. Fouracres' dredger was designed, and is most suitable, for working in soft deposits and in comparatively shallow water. It has never as yet been worked to a depth greater than 10 ft.; but it is believed by the author that for such depths it is the most handy, cheap, and effective dredger yet in use. When designed for deeper cutting it is proposed to alter the arrangement to some extent, and to substitute two spears for the one at present employed. It is proposed to make these spears of iron or steel pipes, and telescopic, so that they would not extend to an unreasonable height above the dredger. Figs. 10 and 11, page 157, show the general arrangement proposed for a dredger capable of dredging 150 cubic yards per engine-hour at a depth of 20 ft. The details of the dredging apparatus itself are shown in Figs. 12, 13, and 14, page 156.

There are two revolving cranes at the bow of the dredger, which carry the dredging scoops; these cranes can either be worked together or separately. The drawings show them designed for working separately, but it would be easy so to arrange the regulating handles that one man could regulate both; in that case, of course, both cranes would revolve simultaneously, and the dredger would not then heel over as it does when only one crane is used.

The scoops of the bucket, which contain about $3\frac{1}{2}$ cubic yards, are similar to those previously described, except that they have double spears L and double closing chains P; the sliding collar W is also differently constructed to carry the extra pulleys which are necessary consequent on the doubling of the chain P; by means of this doubling the run of the collar W is reduced by one half, and the apparatus is consequently more compact. The extra force necessary to close the scoops is gained by the double pulleys in which the main chain B runs. In order to enable one man to do the work which in the dredger now working is done by three men, it is proposed to work the hooks H by means of a spiral spring M placed above a small steam or compressed air cylinder K. By means of the spiral spring, the hooks H are kept constantly in readiness to catch the clutch collar X; but when the hooks have caught the collar and are bearing the weight of the apparatus, the man regulating the machinery admits the steam into the cylinder K; so that as soon as the scoops are empty and the main chain has been sufficiently lifted to take the weight off the hooks, these are opened by the descent of the piston in the cylinder overcoming the force of the spring; and the apparatus is then lowered.

The pressure on the spears C is put on in the same manner, by admitting steam or compressed air to the cylinder G; this presses the blocks F against the racks in the spears. While the scoops are being closed, the attendant keeps his hand on the regulator which controls the valve of the cylinder G; thus he can at any moment release the spears by allowing the steam or air to escape from the cylinder, when the spiral spring N immediately draws the blocks F out of contact with the racks on the spears The teeth on these racks are so constructed that the blocks F would run back in the event of any extreme pressure coming on them, even against the pressure in the cylinder G. Friction blocks might no doubt be substituted for the rack and block F. The tubes C, which play the part of the wooden spears at present in use, are lightly braced together by iron rods. They are steadied above the jib-head by a light guide D attached to the head of the crane.

It is estimated that a dredger constructed on this plan would dredge from a depth of 20 ft. about 1000 cubic yards a day of soft material, at a cost of about $1\frac{1}{2}$ per cubic yard, including establishment, materials, repairs, and an allowance of 10 per cent. for depreciation and interest on first cost. The prime cost of such a dredger would not exceed 2500*l.*

A CABLE ACROSS THE CASPIAN.—All the preparations for laying a submarine telegraph cable across the Caspian Sea are now completed, and the cable itself will be laid by the end of September. The cable will be 150 miles long; will reach from Cape Gurgian to Krasnovodsk, and will cost, it is estimated, 700,000 roubles. Telegraphic communication will be established between Tjikislar and Asterabad; so that telegrams from the former place will be able to be sent by way of Teheran and the Indo-European line to Tiflis.

THE READING (U.S.) IRON WORKS.—The Reading Iron Works, Reading, Pennsylvania, include eight separate establishments, all of which are run at present to their utmost capacity. The total number of hands employed is something over 1500. The company have one furnace in blast, and will light a second in the course of two weeks. The sheet mill was started during the winter and gives employment to 220 hands. The boiler department is busy on tank cars for the Philadelphia and Reading Railway Company, and is turning out 39 oil cars per month, each car having a capacity of 100 barrels. The tube works are very busy, turning out about 80 tons per day. They have recently completed an order for 100 miles of pipes for the new pipe line, and they have a prospect of such a demand that they are enlarging the works, and will shortly be able to weld 150 tons per day. The rolling mill is very busy running double turn, so also the nail mill, which is turning out 1200 kegs per week. The Scott Foundry, which is another department of the same company, is busy on cotton presses, and other heavy machinery. The works recently shipped to Selma, Alabama, a press which weighed 240 tons.

PRICE LIST OF MATERIALS.

THURSDAY, AUGUST 21, 1879.

METALS.

	£	s.	£	s.
ANTIMONY ORE (per ton)—	10	0	11	0
Regulus (star)	47	0	47	10
BRASS (per lb.) –	s.	.	s.	d.
Sheets, 48 × 24	0	7¾	0	8
Yellow metal	0	6½	0	7
CASTINGS TYNE AND CLEVELAND (per ton)	£	s.	£	s.
Girders	4	10	5	10
Chairs	2	15	3	10
Pipes	4	5	5	0
COPPER (per ton)—				
Chili bars	53	15	54	0
Australian	62	0	62	10
English tough, best	60	10	61	10
„ ingots	61	0	62	10
Sheets, &c.	63	10	64	10
Bottoms	74	0	75	0
IRON ORES (per ton)—	s.	d.	s.	d.
Red hematite, blast	12	0	13	0
„ „ puddling	11	0	12	0
IRON PIG (per ton) –				
Barrow No. 1	51	0	53	6
„ „ 2	48	0	51	0
„ „ 3	46	0	48	0
Cleveland No. 1	36	6	37	6
„ „ 3	34	0	35	0
„ „ 4 (Forge)	32	6	33	3
Foundry	31	0	32	6
Welsh (South Wales)	65	0	75	0
„ (North Wales)	60	0	65	0
	No. 1.		No. 3.	
Scotch Pig –	s.	d.	s.	d.
G.m.b., at Glasgow	44	0	42	6
Gartsherrie	47	6	44	0
Coltness	53	6	44	0
Summerlee	45	6	43	0
Langloan	50	0	43	0
Carnbroe	45	6	43	0
Monkland	44	0	42	6
Clyde	45	6	42	6
Govan, at Broomielaw	44	0	42	6
Calder, at Port Dundas	47	0	43	0
Glengarnock, at Ardrossan	45	6	43	0
Eglinton, ditto	44	0	43	0
Dalmellington, ditto	43	6	42	0
Carron, at Grangemouth	60	0	57	6
Ditto, specially selected	65	0	—	
Shotts, at Leith	48	0	44	0
Kinneil, at Bo'ness	—		—	
(The above all deliverable alongside).				
	s.	d.	s.	d.
Shropshire	55	0	80	0
North Staffordshire	45	0	75	0
South „	55	0	70	0
Yorkshire Thornaby pig No. 3.	49	0	53	0
IRON, WROUGHT –	£	s.	£	s.
Cleveland angles	4	17	5	3
„ bars	5	0	5	3
„ puddled bars	3	10	3	15
„ boiler plates	6	0	6	10
„ rails	5	0	5	5
„ ship plates	5	0	5	5
„ sheets	7	0	8	0
„ hoops	7	5	7	15
Scotch bars	5	0	6	0
„ nail rods	6	0	6	10
Staffordshire bars	6	0	7	10
„ plates	6	10	9	10
„ boiler	8	0	9	10
„ hoops	6	10	7	0
Welsh rails S.W.	4	10	5	0
„ bars „	6	0	6	5
„ boiler plates, S.W.	9	0	11	0
„ hoops, S.W.	8	0	8	10
LEAD (per ton)—				
Soft English pig	14	5	14	7
„ „ W.B.	14	0	15	0
Spanish	13	12	14	0
Sheet	17	0	18	10
PHOSPHOR BRONZE – (per ton)	105	0	125	0
QUICKSILVER (per bottle)	5	12	5	17
SCRAP (per ton) –	3	10	4	0
SPELTER (per ton) –				
Silesian, ordinary	16	0	17	0
SPIEGELEISEN (per ton)—				
Best	6	0	0	0
Common	5	0	5	10
STEEL (per ton) –				
Best cast	34	0	50	0
„ double shear	45	0	65	0
„ single „	32	0	50	0
English spring	14	0	22	0
Blister	00	0	00	0
Milan	28	10	30	0
Bessemer rails	4	9	5	0
„ tyres	8	5	8	15
„ axles	9	0	9	5
„ billets	6	0	7	0
„ plates	10	0	0	0
„ angles	9	0	0	0
STEEL CASTINGS (per cwt.) –				
Hydraulic cylinders in the rough not to exceed 6 ft. in length,	s.	d.	s.	d.
guaranteed	26	0	28	0
Do. do. finished	30	0	34	0
Pinions and cog-wheels	25	0	28	0
Hammer tups, faces, swages, 5 cwt. and above	20	0	24	0
Holders-up for rivetting machines, &c., 1½ to 5 cwt.	25	0	26	0
STEEL CASTINGS—*continued*	s.	d.	s.	d.
Side cranks, cross heads, crane wheels, engine slides, &c.	4	0	30	0
Tumbler bars and other castings for dredging purposes	20	0	26	0
SWEDISH IRON (F.o.b) at Gottenburg (per ton)	£	s.	£	s.
Pig	4	5	4	10
Bar rolled	9	0	11	0
„ hammered	11	0	11	10
TIN (per ton) –				
Straits	68	0	68	10
Billiton	64	10	66	0
Banca	00	0	66	0
English ingots	66	0	68	0
English bars	65	10	68	0
English refined	66	10	68	0
Australian	66	0	67	0
TIN PLATES (per box) –	s.	d.	s.	d.
I.C. charcoal	20	6	22	6
I.X. „	25	0	28	0
I.C. coke	17	0	20	0
I.X. „	22	0	25	0
ZINC (per ton) –	£	s.	£	s.
Sheets, English	18	0	19	0
WIRE, fencing	10	0	12	10
„ Telegraph (galvanised)	14	0	18	0

COALS AND COKE.

COALS (per ton) –	s.	d.	s.	d.
Barrow	9	0	11	0
Bristol	9	0	10	6
Derbyshire	8	0	10	6
Lancashire	8	0	10	0
Newcastle and Durham	8	6	12	0
Scotch	7	0	10	0
Staffordshire	8	6	11	6
Welsh	9	0	10	0
Yorkshire	8	0	12	0
COKE –				
Cleveland	9	0	9	6
Durham	15	0	17	0

OILS, GREASE, & LUBRICATORS.

OILS (per tun) –	£	s.	£	s.
Seal, brown	23	0	23	10
„ pale	28	0	29	0
Sperm body	55	0	56	0
Whale, pale	25	0	25	10
„ yellow	24	0	25	0
Lard	36	0	36	10
GLUE	30	0	50	0
PETROLEUM –	s.	d.	s.	d.
Fine (per gallon)	0	6	0	6¼
COAL oil, refined	0	7	0	7¼
RANGOON engine oil	2	6	2	9
LINSEED oil	27	6	28	0
PITCH (per cwt.) –	s.	d.	s.	d.
British	5	6	5	9
Archangel	7	6	8	0
PLUMBAGO (per cwt.) –				
Ceylon lump	11	6	12	0
„ chips	9	6	11	0
„ dust	7	6	8	0
RAILWAY GREASE (per cwt.)—Rose's	28	0	00	0
Pritchard, Offer and Co.'s concentrated	60	0	00	0
RESIN (per cwt)	4	0	4	3
TALLOW (per cwt.)				
N. American	00	0	00	0
S. American beef	00	0	00	0
„ sheep	00	0	00	0
Australian beef	32	6	33	0
„ sheep	33	6	34	6
St. Petersburg, Y.C.	36	0	37	0
English, town	32	0	34	0
Rough, English	12	0	13	6
TAR—Stockholm (per barl.)	20	6	22	0
Archangel	15	6	00	0
TURPENTINE - Spirit— American (casks)	21	0	21	3
WIPINGS, engine (per cwt.)	20	0	35	0

CHEMICALS, &c.

ACIDS—	s.	d.	s.	d
Aquafortis (per lb.)	0	4¼	0	0
Sulphuric acid (per lb.)	0	0¾	0	0
Sulphuric acid, brown	0	0½	0	0
AMMONIA – Muriate (per ton)	£	s.	£	s.
	29	0	35	0
ARSENIC—	s.	d.	s.	d.
White, lump (per cwt.)	24	0	26	0
Powdered (per cwt.)	8	6	9	0
BLEACHING powder per cwt.	5	9	6	0
BORAX –refined (per cwt.)	35	0	38	0
BRIMSTONE (per ton) –	£	s.	£	s
Rough	5	10	6	0
Flour	11	0	13	10
Roll	8	10	9	0
COPPERAS –green	45	0	50	0
COPPER — Sulphate (per cwt.)	s.	d.	s.	d.
	18	6	20	0
LEADS, SALTS, &c., (per cwt.)				
Acetate, best	18	0	19	0
Brown „	22	0	23	0
Red	14	0	16	0
White	18	0	19	0
LITHARGE (per cwt.)	19	0	20	0
POTASH—Bichromate (per lb.)	0	4	0	4½
SALTPETRE (per cwt.)				
English refined, kegs	18	0	19	0
Bombay	00	0	00	0
Bengal	18	0	18	6
SODA Caustic	12	6	13	0
„ Crystals (per ton)	£3	5	£3	10

THE "THREE YEARS PURCHASE SYSTEM" AS APPLIED TO MACHINERY.

A CASE of considerable public interest and of importance to engineers especially, was decided in the Halifax County Court on the 12th inst. before Mr. J. W. de Longueville Giffard, the judge. The proceedings were in the form of a motion to the court on the part of Messrs. John Fowler and Co., of the Steam Plough Works, Leeds, for an order directing Mr. J. L. Learoyd, the trustee under the liquidation of Messrs. Reside Cliffe and Thomas, coal merchants and carriers, of Barkisland, near Halifax, to hand over to Messrs. Fowler and Co. a traction engine which they had supplied to the debtors on a hire and purchase agreement. The facts were as follows:

In 1877 an agreement was entered into between the parties by which, in consideration of 514*l*. 15s., payable by instalments, Messrs. Fowler and Co. agreed to permit the hirers to use the said engine for 18 months, and at the expiration of that time agreed to sell it to them for a further nominal consideration of 10*l*. The agreement was in the form which Messrs. Fowler and Co. adopt, and provided amongst other things that the engine should be kept in repair by the hirers, and that they should always keep upon it a nameplate bearing the words "John Fowler and Co., owners." When the 18 months expired a considerable portion of the instalments were in arrear, and at the request of the hirers, Messrs. Fowler and Co. agreed that they should continue to keep the engine on the terms of the agreement as far as they would apply; time being given for payment of the instalments in arrear. A few months afterwards while a balance of the instalments still remained in arrear, the hirers filed a petition for liquidation of their affairs, and a receiver was appointed, who took possession of the engine as part of their estate, and refused to give it up to Messrs. Fowler and Co. who formally demanded it from him as their property. A trustee was afterwards appointed; and on his refusal to hand over the engine Messrs. Fowler and Co. commenced proceedings. At the hearing of the motion on Tuesday it was proved that the traction engine was, at the date when the petition was filed, in the hands of the hirers on the terms of the agreement so far as they would apply to an extension beyond the 18 months originally agreed for, and that throughout the whole of the time that the engine was in the possession of the hirers, and at the date when the petition was filed, there was affixed to it the plate bearing the words "John Fowler and Co., owners;" and evidence was given by a number of witnesses from various parts of the country to the effect that the custom of letting out certain kinds of machinery (including traction engines) on the hire and purchase system is an established and well-known custom. It was contended by the trustee that at the date when the petition was filed, the 18 months having expired, the agreement was at an end; and that the debtors had ceased to be in the position of hirers, and had in fact become the purchasers of the engine; and also that whether this were so or not, there was no custom of letting out machinery of the description in question to people carrying on the same business as the debtors; and that the engine at the date of the petition was in the order and disposition of the debtors, as the reputed owners of it, and consequently passed to the trustee as part of their estate. No evidence was called on behalf of the trustee. After hearing the evidence addressed on behalf of Messrs. Fowler and Co., and the argument of counsel on both sides, his honour made an order directing the trustee to return the engine to Messrs. Fowler and Co. within a month, or to pay to them the arrears of the instalments together with the nominal consideration mentioned in the agreement, and to pay the costs of the proceedings. Mr. E. Tindal Atkinson (instructed by Messrs. Eddison and Eddison, solicitors, Leeds) appeared for Messrs. Fowler and Co., and Mr. T. H. Jordan (instructed by Messrs. Holroyde and Smith, solicitors, Halifax) appeared for the trustee.

AMERICAN LOCOMOTIVE BUILDING.—The Baldwin Works, Philadelphia, which commenced operations in 1831, have lately completed their 4707th engine. This shows an average of five weekly for 47 years. There are 2000 men at work in the shops, and sometimes as many as nine locomotives are turned out in a single week. The company have on their books at present the following orders for locomotives: 15 for the Chicago, Burlington, and Quincy Railroad, 16 for the Chicago and Alton Railroad, and six for the Denver and Rio Grande line, together with extensive orders from South America and Australia, making a total of about 100 locomotives now in course of construction at the works. The company have shipped this year 45 locomotives from New York to foreign ports. The amount of business done this year by the works is regarded as an indication of a steady advance in the locomotive trade, and not as anything exceptional.

IRON AND STEEL LOCOMOTIVE BOILERS.—Mr. S. J. Hayes, of the Illinois Central Railroad, states that recent experience has taught him that steel is not so well adapted for the cylinder part of a locomotive boiler as a good quality of iron. There are several engines now in service on this road with boilers built in 1856, the outside shells of which were built of Lowmoor iron. These boilers have been in service twenty-three years, and there is but little sign of corrosion or pitting in the sheets. The sheets in the bottom of the cylinder part of these boilers have never been renewed, and are to all appearances in good condition at present. In 1874 two new boilers were built. The shell of one of these was made of a high grade of steel, the other of iron. Both engines were put in the same service on the same section of the road, and made equal mileage. When the flues were removed the steel boiler was found to have suffered the most from corrosion, and was pitted to such an extent that it was necessary to put lining plates on the inside along the bottom of the cylinder part, to protect it from further corrosion. The shell of the iron boiler was somewhat corroded, but not nearly so much as the steel one. Another boiler, built in 1876, of open-hearth steel, after running 73,166 miles on a section of the line where the water is not considered bad, was found to have been pitted and corroded in the bottom of the cylinder part. At one place, near the first seam back of the front flue sheet, a furrow 9 in. long, and varying from one-twelfth to one-sixteenth of an inch in depth, had been formed during the short time the boiler was in service. At another place, close to the front flue sheet, and directly opposite the hand-hole used, for washing out that portion of the boiler, a spot 2 in. in length, 1 in. in width, and about one-sixteenth of an inch in depth was eaten out of the metal. All the steel boilers built by the Illinois Central Railroad Company within the past five years have been pitted and furrowed at the seams from the effects of corrosion, and to a much greater extent than boilers the shells of which were made of a good quality of iron. This experience has led Mr. Hayes to believe that Lowmoor or any other good quality of iron is better adapted for the cylinder part of boilers on this line than steel plates. Diametrically opposed to this result of the use of steel for locomotive boilers are the facts gathered by Mr. James M. Boon, of the Pittsburgh, Fort Wayne, and Chicago Railroad, who holds that steel is the best material for boilers, with either wood or coal as fuel, and who finds iron to be more liable to corrosion than steel. The company's first steel boilers were built in 1871, and they never found any corrosion, furrows, or pitting inside of them. Iron boilers, of the same size, same service, and using the same water, have corroded on the inside in six years' service so badly that sheets had to be cut out and replaced with new ones. Mr. Boon believes this pitting is produced by both mechanical and chemical action. The expansion and contraction of the sheets of iron open the fibre, water then enters, and pitting ensues. Steel being more homogeneous than iron, this action does not so readily take place. The only action of this kind which the company have had on their steel boilers was at the inside corners of the firebox at the mud ring. They have had less trouble with their steel than with iron boilers. To overcome this, Mr. Boon believes it would be an advantage to have the lower ends of the firebox sheets rolled thicker at about the level of the fire.