THE IRON AND STEEL INSTITUTE.

LAST week we reported the proceedings of the Institute down to Wednesday evening, the 6th inst. Business was resumed on Thursday morning, May 7th, Dr. Percy in the chair. The president opened the proceedings by referring to some Admiralty experiments made to determine the value of tar as a preservative of wrought iron; and he showed samples. The first paper read was by Mr. Watson Smith, "On Recent Results with Regard to Bye-Products Obtained in Coking Coal in the Simon-Carvès Oven." This was a Chemical paper, of next to no general interest.

The second paper was by Mr. Henry Simon, of Manchester—

ON RECENT RESULTS AND FURTHER DEVELOPMENT OF THE SIMON-CARVES COKING PROCESS.

This was a lengthy paper, describing the process of working the ovens. During the twelve months which have elapsed since the last summer meeting of the Institute, a number of further licences under the Simon-Carvès patents have been successfully started in England. Firstly, fifty ovens belonging to the Bearpark Coal and Coke Company, Durham; secondly, thirty-five ovens belonging to the representatives of the late John Wedgewood, Bignall Hill Collieries, Newcastle, Staffordshire; thirdly, twenty-five ovens belonging to the Altham Collieries Company, Whinney Hill, Accrington. The construction of the fifty ovens belonging to the Bearpark Company was begun in December, 1883, and finished in December, 1884. The construction of the thirty-five ovens belonging to the representatives of the late John Wedgewood was begun in February, 1884, and finished in April, 1885. The twenty-five ovens belonging to the Altham Colliery Company were begun in October, 1883, and finished in April, 1885. The ovens at the Bearpark Collieries have a length increased by 1ft. as against the dimensions used at the establishment of the Messrs. Pease and Partners, at Crook, near Darlington. Each of the ovens at Bearpark is charged with a quantity of 4½ tons of coal; and out of the total number of fifty, about twenty-two per day are at present drawn and re-charged, except on Sundays, when only fifteen are drawn. This gives only a daily average of twenty-one ovens instead of twenty-five. The time for coking at Bearpark is therefore at present still over forty-eight hours.

A further step in advance has been made in the utilisation of bye-products at the works of the Terrenoire Company, near St. Etienne, where the gas, after having undergone the whole of the treatment for the deprivation of bye-products described in my former papers, are, before being burned in the ovens, successfully subjected to a further process for the extraction of benzol and other light hydrocarbons. The results achieved are certainly interesting and satisfactory. A quantity of 5·5 lb. of benzol per ton of coal, worth at the present low rate about one shilling, is being extracted and sold from these gases, over and above the quantities of tar and ammonia given in former indications. For this purpose the gases, after the tar and ammonia is extracted, and before burning them around the coke ovens, are subjected to a further treatment, whereby the light hydrocarbons, such as benzol, which are still retained in them, are separated and obtained in a commercial form, instead of, as heretofore, allowed to be burned with the gases.

A further development in the collection of bye-products is the manufacture of sulphate of ammonia out of ammonia water. Messrs. Pease, at their Crook establishment, near Darlington, have lately entered upon this manufacture, and by the addition of such plant a further considerable pecuniary advantage is realised by the coke manufacturer with little trouble, there being no reason for leaving this profit to the chemical manufacturer. Besides the manufacture of sulphate of ammonia, it may in certain cases be advantageous to erect apparatus for the concentration of ammonia liquor, or for the manufacture of salammoniac, which would bring a further extra profit per ton of coal into the pockets of the coke maker, who, until now, has been content to save it to the chemical manufacturer. The manufacture of sulphate of ammonia, concentrated liquor of ammonia, and salammoniac, is now being successfully carried on in one and the same set of patent apparatus.

The third paper read was by Professor Armstrong, F.R.S., London, entitled:—

NOTE WITH REFERENCE TO THE METHODS PROPOSED FOR COKING COAL AND RECOVERING VOLATILE MATTERS.

This also was a chemical paper, the passage in which possessing most general interest runs as follows:—"Finally, let me again point out that we know practically nothing of what happens when coal is distilled, or of the conditions most favourable to the production of the valuable constituents of tar. Until we possess adequate knowledge on these points the coking of coal and the manufacture of gas from coal and oils are empirical operations, and cannot be conducted scientifically. It would not be difficult to gain the required information, but the aid of the chemist must be sought, and the experiments must be on a moderately large, and therefore expensive, scale. Our private dabbling with tars from various sources can never lead to a really satisfactory result. The interests involved are so great, the subject is one of such national importance, that failure to initiate and execute the necessary systematic experiments without further loss of time is simply inexcusable."

The last paper read on Thursday was by Mr. J. Head, of London, "On a Modified Form of the Siemens Old Type Gas Producer, by means of which the Gases are Enriched, and the Bye-Products may be Recovered." This paper was practically a statement of the advantages of the Siemens furnace. Ill-natured folk might, indeed, call it an advertisement, in which respect it would only resemble far too many of the papers now read before scientific societies. All four papers were discussed together, the discussion taking the form of a general argument as to the various merits of the various systems of coking now in the market. In fact, it was a species of triangular duel concerning the Simon-Carvès, the Coppée, and the Siemens system.

On Friday the first paper read was by Mr. Carnegie

ON NATURAL GAS FUEL, AND ITS APPLICATION TO MANUFACTURING PURPOSES.

The author described at considerable length and with much graphic power what he saw during a recent trip in Pittsburgh.

The territory underlaid with natural gas has not yet been clearly defined. At the principal field, that of Murraysville, from which most of the gas is obtained to-day, the author found, upon his visit to that interesting region last autumn, that nine wells had been sunk, and were yielding gas in large quantities. One of these was estimated as yielding 30,000,000 cubic feet in twenty-four hours. This district lies to the north-east of Pittsburgh, running southward from it towards the Pennsylvania Railroad. Gas has been found upon a belt averaging about half a mile in width for a distance of between four and five miles. Beyond that, again, we reach a point where salt water flows into the wells and drowns the gas. Several wells have been bored upon this belt near the Pennsylvania Railroad, and have been found useless from this cause. Geologists tell us that in this region a depression of 600ft. occurs in the strata, but how far the fault extends has not yet been ascertained. Wells will no doubt soon be sunk southwards of the Pennsylvania Railroad upon this half-mile belt. Swinging round towards the south-west, and about twenty miles from the city, we reach the gas-fields of Washington County. The wells so far struck do not appear to be as strong as those of the Murraysville district, but it is possible that wells equally productive may be found there hereafter. There are now four wells yielding gas in that district, and others are being drilled. Passing still further to the west, we reach another gas territory, from which manufacturing works in Beaver Falls and Rochester, some 28 miles west of Pittsburgh, receive their supply. Proceeding with the circle we are drawing in imagination around Pittsburgh, we pass from the west to the north-west without finding gas in any considerable quantity until we reach the Butler gas field, equidistant from Pittsburgh on the north-west, with Washington County wells on the south-west. Proceeding now from the Butler field to the Alleghany river, we reach the Terentum district, still about 20 miles from Pittsburgh, which is supplying a considerable portion of the gas used. Drawing thus a circle around Pittsburgh, with a radius of 15 to 20 miles, we find four distinct gas-producing districts. In the city of Pittsburgh itself several wells have been bored; but the fault before mentioned seems to extend towards the centre of the circle, as salt water has rushed in and rendered these wells wholly unproductive, although gas was found in all of them.

The author spent a few days very pleasantly last autumn driving with some friends to the two principal fields, the Murraysville and the Washington County. In the former district the gas rushes with such velocity through a 6in. pipe, extending perhaps 20ft. above the surface, that it does not ignite within 6ft. of the mouth of the pipe. Looking up into the clear blue sky, you see before you a dancing golden fiend, without visible connection with the earth, swayed by the wind into fantastic shapes, and whirling in every direction. As the gas from the well strikes the centre of the flame and passes partly through it, the lower part of the mass curls inward, giving rise to the most beautiful effects gathered into graceful folds at the bottom—a veritable pillar of fire. There is not a particle of smoke from it. The gas from the wells at Washington was allowed to escape through pipes which lay upon the ground. Looking down from the roadside upon the first well we saw in the valley, there appeared to be an immense circus ring, the verdure having been burnt, and the earth baked by the flame. The ring was quite round, as the wind had driven the flame in one direction after another and the effect of the great golden flame lying prone upon the earth, swaying and swirling with the wind in every direction, was most startling. The great beast Apollyon, minus the smoke, seemed to have come forth from his lair again. The cost of piping is now estimated, at the present extremely low prices, with right of way, at £1500 sterling per mile, so that the cost of a line to Pittsburgh may be said to be about £27,000 sterling. The cost of drilling is about £1000 and the mode of procedure is as follows:—A derrick being first erected, a 6in. wrought iron pipe is driven down through the soft earth till rock is reached from 75ft. to 100ft. Large drills, weighing from 3000 lb. to 4000 lb., are now brought into use; these rise and fall with a stroke of 4ft. to 5ft. The fuel to run these drills is conveyed by small pipes from adjoining wells. An 8in. hole having been bored to a depth of about 500ft., a 5⅝in. wrought iron pipe is put down to shut off the water. The hole is then continued 6in. in diameter until gas is struck, when a 4in. pipe is put down. From forty to sixty days are consumed in sinking the well and striking gas. The largest well known is estimated to yield about 30,000,000 cubic feet of gas in twenty-four hours; but half of this may be considered as the product of a good well. The pressure of the gas as it issues from the mouth of the well is nearly or quite 200 lb. per square inch. One of the gauges which he examined showed a pressure of 187 lb. Even at works where they use the gas, nine miles from the well, the pressure is 75 lb. per square inch. At one of the wells, where it was desirable to have a supply of pure water, he found a small engine worked by the direct pressure of the gas as it came from the well; and an excellent supply of water was thus obtained from a spring in the valley. Eleven lines of pipe now convey gas from the various wells to the manufacturing establishments in and around Pittsburg. The largest of these for the latter part of the distance is 12in. in diameter. Several are of 8in. throughout. The lines originally laid are 6in. in diameter. Many of the mills have as yet no appliances for using the gas, and much of it is still wasted. It is estimated that the iron and steel mills of the city proper require fuel equal to 166,000 bushels of coal per day, and though it is only two years since gas was first used in Pittsburgh, it has already displaced about 40,000 bushels of coal per day in these mills. Sixty odd glassworks, which required about 20,000 bushels of coal per day, mostly now use the natural gas. In the works around Pittsburgh, beyond the city limits, the amount of coal superseded by gas is about equal to that displaced in the city. The estimated number of men whose labour will be dispensed with in Pittsburg when gas is generally used is 5000. It is only a question of a few months when all the manufacturing carried on in the district will be operated with the new fuel. The author then went on to show that this gas is of immense heating power, as the following tables prepared by Mr. Ford, of the Edgar Thomson steel works, will show:—

Analyses of Natural Gas.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Carbonic acid	0·8	0·6	0·0	0·4	0·0	0·30
Carbonic oxide.. ..	1·0	0 8	0·58	0·4	1·0	0·60
Oxygen	1·1	0·8	0·78	0·8	2·10	1·20
Olefiant gas	0·7	0·8	0·98	0·6	0·80	0·6
Ethylic hydride ..	3·6	5·5	7·92	12·30	5·20	4·8
Marsh gas	72·18	65·25	60·70	49·58	57·85	75·16
Hydrogen	20·02	26·16	29·03	35·92	9·64	14·45
Nitrogen	0·0	0·0	0 0	0·0	22·41	2·89
Heat units in 1000 cubic feet	728,746	698,852	627,170	745,813	592,380	745,591

Analyses of Siemens Producer Gas.

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Carbonic acid ..	3·9	8·6	9·3	1·5	6·1
Carbonic oxide ..	27 3	20·0	16·5	23·6	22·3
Hydrogen	0·0	8·7	8·6	6·0	28·7
Marsh gas	1 4	1·2	2·7	3·0	1·0
Nitrogen	67·4	61·4	62·9	65·9	41·9
Heat units in 1000 cubic feet	93,966	97,184	99,074	114,939	164,164

Now comparing the heating power of this gas with bituminous coal, taking as a basis a coal slightly above the general average of the Pittsburgh coal, viz.:—

	Per cent.
Carbon	82·75
Hydrogen	5·31
Nitrogen	1·04
Oxygen	4·64
Ash	5·31
Sulphur	0·95

It is found that 38 lb. of this coal contain 146,903,820 heat units. Then 54·4 lb. of this coal contain 210,069,640 heat units, or 54·4 lb. of coal is equal in its heating power to 1000 cubic feet of natural gas. If the coal cost 5s. per ton of 2000 lb., then 54·4 lb. costs 1·632 pence, and 1000 cubic feet of gas is worth for its heat units 1·632 pence. As the price of coal increases or decreases the value of the gas will naturally vary in like proportions. Thus, with the price of coal at 10s. per ton, the gas will be worth 3·264 pence per 1000 cubic feet. If 54·4 lb. of coal is equal to 1000 cubic feet of gas, then 1 ton, or 2000 lb., is equal to 36,764 cubic feet, or 2240 lb. of coal is equal to 40,768 cubic feet of natural gas. If we compare this gas with anthracite coal, we find that 1000 cubic feet of gas is equal to 58·4 lb. of this coal, and 2000 lb. of coal is equal to 34,246 cubic feet of natural gas. Then, if this coal cost 26s. per ton, 1000 cubic feet of natural gas is worth 9½d. for its heating power.

The discussion turned almost wholly on the way in which this gas was produced. Part was taken in it by Mr. Bauermann, Mr. Bell, Professor Armstrong, and others.

The last paper read was by Dr. Wedding, "On the Properties of Malleable Iron Deduced from its Microscopic Structures." This paper was lengthy, and does not admit of condensation. It was to all intents and purposes a set of descriptions of the appearances presented by various specimens of iron under the microscope; and as no illustrations were shown, the result was unsatisfactory. Indeed, it is very difficult to see in what the value of such a paper lies. We regret to say this because Dr. Wedding has no doubt worked very hard for years, but it is extremely difficult, if not impossible, to draw any deductions whatever from the paper. The discussion was confined to Mr. Bauermann, who expressed his regret that the author showed nothing, and Sir Henry Bessemer, who said that with regard to the crystallisation of iron or steel that had undergone fusion, very different results were obtained according to the size and form of the crystals; and this again was dependent on the perfect stillness or otherwise of the mass under operation. Nearly thirty years ago he was anxious to see how the presence of phosphorus affected crystallisation; for he suspected that the large crystals from which his process at that early period was suffering were due to the presence of that deleterious element. He determined to allow the mass to cool as slowly as possible, and for that purpose he had a large hole made in the ground, 4ft. in diameter, lined with brick. A charcoal fire was kept in it for three or four days, and when it was heated to a white heat a mass of Bessemer iron, wholly decarbonised, was poured into it. It was then covered with hot sand, so that the escape of heat was rendered almost impossible, except by slow percolation. At the end of five or six days the mass was taken out and allowed to cool, and he found that a piece 15in. in diameter was readily broken through by a single blow of a large hammer. By taking it in one hand and striking it with a 2-lb. hammer, he could detach showers of crystals. The cohesion of the mass had been rendered almost *nil* by the perfection of the crystals. Some of them were cubes of nearly the size of common dice, and were beautifully polished and white. They could be hammered out into discs as large as a sixpenny piece, showing that the metal was malleable, and it owed its excessive weakness only to the perfect crystallisation which had been encouraged by that particular process. That, perhaps, was one of the points which practical men would, with a little consideration, no doubt, apply in some shape or other. It was quite impossible, when iron was produced in a malleable state, and recarburetted by putting very highly carburetted metal into it, that the simple pouring of these two elements together could produce a homogeneous mass. In every ingot of ordinary iron or steel there were strata of the malleable iron mixed with the carbonising metal, and it was only by a thorough admixture of those parts before casting took place that they could hope to get anything like a homogenous result. Even that, as Dr. Wedding had shown, was not sufficient to prevent the formation of different kinds of crystallisation, as though some particles elected to form crystals of themselves, and, having abstracted certain atoms to form that crystal, they left in their immediate neighbourhood and surrounding them another compound of iron containing more or less carbon than the central nucleus was formed of.

Votes of thanks were passed to the Institution of Civil Engineers for the use of their rooms, and to the president for presiding, and the meetings terminated.

THE INVENTIONS EXHIBITION.—WAR MATERIAL.

In our number of May 10th we gave an account of the exhibits sent from the Royal Arsenal Gun Factories, Carriage Department, and Laboratory. These are at the foot of the steps at the entrance to the middle court. The 8in. breech-loading gun is a prominent object, and indicates the commencement of the groups. Waltham Abbey is on the left face of the centre line of groups advancing from the steps, and Enfield on the right, after passing the exhibits of the departments mentioned above.

Colonel C. B. Brackenbury, R.A., superintendent of the Royal Gunpowder Factory at Waltham Abbey, sends the following exhibits:—Models of gunpowders are furnished from 1862 to present date, as well as of gun-cotton. The following is a list of them:—

List of Gunpowder and Gun-cotton (Models).

F.G. (fine grain)	16 to 32 mesh	7-pr. R.M.L.
L.G. (large grain)	8 to 16 mesh	68-pr. gun, 8in. howitzer.
R.L.G. (rifle large grain)	4 to 8 mesh	9-pr. gun, 64-pr. R.M.L., 40-pr. R.M.L., 25-pr. R.M.L., 16-pr. R.M.L.
R.F.G. (rifle fine grain)	12 to 20 mesh	Snider rifle.
R.F.G.[2] (rifle fine grain)	12 to 20 mesh	Martini-Henry rifle and Gardner and Gatling guns.
R.L.G.[2] (rifle large grain)	3 to 6 mesh	9-pr. R.M.L. gun, 7-pr. R.M.L., 13-pr. R.M.L., 16-pr. R.M.L., 4in. B.L. gun, 40-pr. B.L. gun.
P. (pebble)	⅝in. cubes	7in. R. M. L. gun, 80-pr. R.M.L., 64-pr. R.M.L., 25-pr. R.M.L., 6in. B.L. gun, 4in. B.L. gun, 12-pr. B.L. gun, 12in. R.B.L. gun.
P.[2] (pebble)	1½in. cubes	5in. B.L. gun, 6in. B.L. gun, 12·5in. R.M.L. gun, 12in. R.B.L. gun.

Prismatic black, 0·98in. in height, diameter over sides 1·37in., 8in. B.L., 9·2 B.L., 10·4 B.L.
Prismatic C[2] ... 2in. in height, diameter over sides 2·35in., hole 0·575in., 10·4in. B.L., 12in. B.L., 8in. B.L., 9·2in. B.L.
C[2] ... ... 2in. in height, diameter 1·75in., 8in B.L., 9·2in. B.L., 10·4in. B.L., 12in. B.L.
Prism C[1] Brown ("Cocoa") 0·98in. in height, diameter over sides, 1·37in.

Rifled pistol	20 to 36 mesh	Rifled pistol.
M.G.[1]	7 to 14 mesh	Nordenfelt gun.

	Gun-cotton.
Slab 6⅛in. × 6⅛in. × 1¾in.	2½ lb.
Slab 6⅛in. × 6⅛in. × 1⅜in.	2 lb.
Slab 6⅛in. × 6⅛in. × 1⅛in.	1½ lb.
Primer 5 in. × 2 in.	1½ lb.
Primer 3$\frac{1}{10}$in. × 2 in.	9 oz.
Primer 1¾in. × 1⅜in.	2 oz.
Primer 1¼in. × 1¼in.	1 oz.

Model representing charge of gunpowder for the proposed 156-ton R.B.L. gun (1400 lb.).
Model representing charge of gun-cotton for head of 14in. Whitehead torpedo.
Cartridge representing charge of gunpowder for 68-pounder gun.

These samples of powder to some extent register the history of powder and its stages of development of grain from quick-burning kinds suitable to small charges and short guns to the enormous pellets now employed, which have fulfilled the requisite conditions of gradual action so completely that it is difficult to understand fully how the results are actually achieved. The pressure is now brought on so gradually and developed so far up the bore that, as we have noticed under the head of the Gun Factories and Royal Laboratory, the guns are being strengthened further forward, and the fuses have to be modified considerably. The enormous model charge for the new 160-ton gun cannot fail to be an object of popular wonder if the public generally recognise that it represents a charge of powder, on which point we have some doubt.

The safety electric lamps of Waltham Abbey we reserve for our next notice, together with the original form of lamp of Major Watkin.

Colonel Arbuthnot, R.A., sends from Enfield a complete series of small arms and swords, and other hand arms made in the department, as well as lances, boarding pikes, Horse Guard's breast-plate, &c. There will also be found a five-barrelled Gardner machine gun, weighing 4 cwt. 0 qrs. 13 lb., and a two-barrelled one, weighing 1 cwt. 3 qrs. 16 lb. These guns were adopted, after being tried in the competition at Shoeburyness in 1881, of which a report, with cuts, of the arms was given in THE ENGINEER, January 21st and February 18th, 1881. The five-barrelled gun is shown in Fig. 6, not on a fixed stand, but on a field carriage, with the breech open. There are also five and four-barrelled Nordenfelt, the latter having an inch bore. These are employed chiefly in the Navy. The model of the Benbow will be seen to carry in her equipment ten of the latter and four of the former. The machine guns and also the bayonets are matters of special interest at the present time, since their powers have been so recently tried in the Soudan and Canada; but we notice the machine guns again under the heading of their own inventors' exhibits.

Next to Enfield comes Templar's balloon equipment, which is represented by a small balloon and a cylinder for containing hydrogen gas.

This forms part of the Royal Engineer Department, which consist chiefly of mining gear. There is a model illustrating generally the system of Captain Ruck, R.E. The mines are caused to act on the contact of the vessel, but not directly by it. The contact actually makes a signal which is seen by an operator, and also puts the mine in contact and its connections out of circuit with the other mines of the system. The operator fires, and the mine in its explosion destroys its own connection with the rest of the circuit, and prevents water contact by means of a special fuse. Captain Ruck is also the designer of a very simple but useful shackle, which is kept closed by the bite of india-rubber on a conical bolt. India-rubber does not bear a hot climate ordinarily, but perhaps might do so under water. There is a Le Monnier's light projector, with wide spread for searching and parallel rays for signalling and projecting on a special spot. Also a glass mirror of Captain Cardew's, which costs about £7, and replaces a metal mirror costing £240. It was supposed that bullets would only perforate the latter, which action if unaccompanied by distortion would not greatly detract from its power. Cardew's mirror being in a frame, might probably be perforated by a bullet without further fracture than a round hole, but if broken up can be very quickly replaced by another. Cardew has also an electric shunt to preserve a circuit from destruction in case of a sudden injury on service. There are models of bridges, but we did not notice any new feature in them. The Royal Engineer exhibits are in charge of a singularly able and painstaking corporal.

FIG. 1

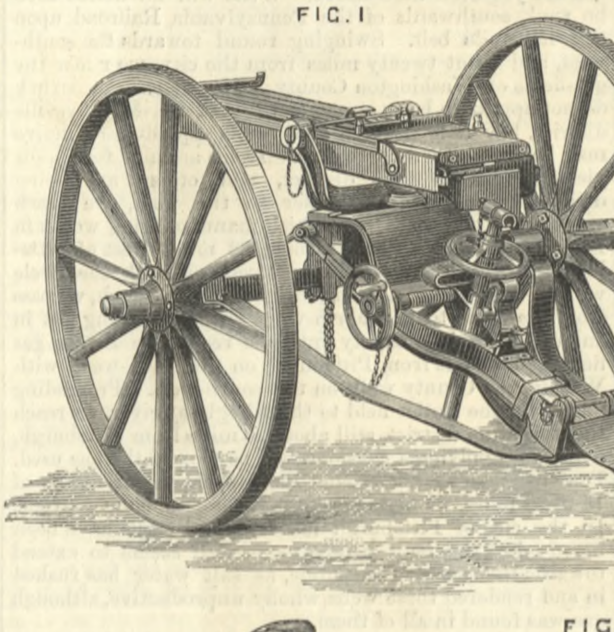
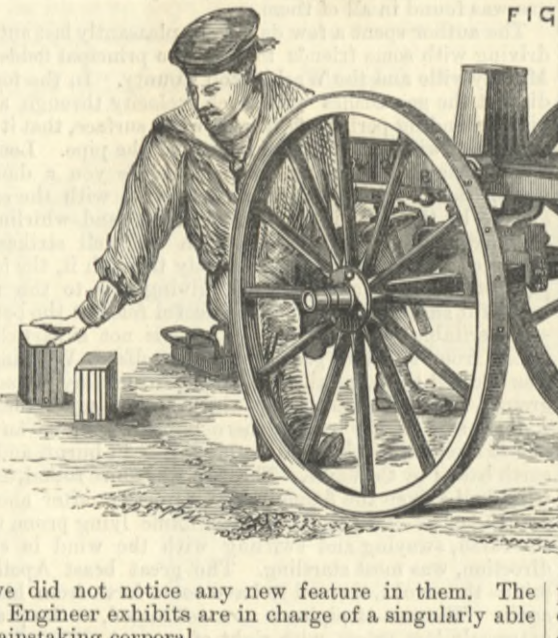


FIG. 2



The Elswick Ordnance Company exhibit designs here as well as in the department of naval architecture. We propose to notice their exhibits as a whole.

Nordenfelt has specimens of machine guns and also quick-firing guns. There is some difficulty in distinguishing between these two classes. Speaking generally, a quick-firing gun is a single-barrelled piece, discharging projectiles running from 1 lb. upwards, with action enabling a rapid fire to be kept up, but fed by hand with cartridges. The arm has come in owing to the obvious scope for such fire against unarmoured parts of ships and torpedo boats. The two features of size and hand loading which distinguish this piece from machine guns are not in all cases maintained, since Hotchkiss has a four-pounder machine gun and Nordenfelt is bringing out quick-firing guns fed by hoppers. The distinction, therefore, appears to be in jeopardy. Nordenfelt exhibits the following pieces:—(1) Twelve-barrelled volley-firing machine gun rifled calibre. The gun weighs 250 lb., naval carriage 236 lb., field carriage 566 lb., limber 514 lb. empty. It fires 1200 rounds per minute, or 720 per half minute. (2) Three-barrelled volley-firing machine gun weighs 56 lb., on tripod carriage, with axle and wheels weighs 221 lb., firing 350 to 400 rounds per minute, or 1000 rounds in 2 min. 40 sec. (3) Single-barrelled machine gun, weighing 15 lb., tripod stand 17 lb., firing 180 rounds per minute, 100 in a half minute. (4) Five-barrelled volley-firing machine gun, rifle calibre, weight 130 lb., naval carriage 133 lb., field carriage 281 lb., firing 600 rounds in a minute, and in the official trial 3000 rounds in 5 min. 47 sec., and 1000 in 1 min. 57 sec. This piece is exhibited both on field and tripod stand. (Figs. 1 and 2 show it as fired in trial). (5) Two-barrelled 1in. volley firing gun, firing a 7·2 oz. projectile with a velocity of 1475ft. per second, piercing 1in. iron at 300 yards, firing 100 rounds per minute. (6) Single-barrelled 1¼in. quick-firing shell gun—gun weighing 100 lb., boat non-recoil, boat carriage 150 lb., projectile 14·25 oz., with a bursting charge of 304 grains. This is intended to attack torpedo boats. (7) Single-barrelled 1½in. 1½-pounder magazine gun firing shell bullet. The gun weighs 1·77 cwt., non-recoil ship carriage 2·5 cwt., projectile 1·5 lb., bursting charge 400 grs., for attack of torpedo boats. (8) 1·65in. 2½-pounder quick-firing gun—weight 3·1 cwt., non-recoil carriage, cone, and socket 3·75 cwt., projectile 2½ lb., bursting charge of steel bullet 550 grs., common shell 700 grs., rate of firing 25 rounds per minute, velocity at muzzle 2008ft., perforation at 1000 yards 2·27in. wrought iron. (9) Single-barrelled 2¼in. 6-pounder quick-firing shell gun—weight 6 cwt., non-recoil carriage and cone 11·5 cwt., recoil 5·5 cwt., bursting charge for steel bullets 1400 grs.; shrapnel contains 135 bullets, rate of firing 24 rounds per minute, initial velocity 2130ft. per second, perforation at 600 yards 3in. of steel, obtained at Portsmouth in 1884. In 1885 at Portsmouth, 186 rounds were fired from a non-recoil carriage in twenty minutes, and from a recoil carriage in twenty minutes.

The Admiralty in this department exhibit a Whitehead torpedo, showing section of the buoyancy chamber, engine-room and head, with gun-cotton charger, the secret chamber being closed. There is a model of a boat showing outrigger torpedo, besides a small one of the Polyphemus; also detonators and tubes for torpedoes.

Colonel Clerk has a gun-elevating platform, Sufts' indicator safety arrangement for Martini-Henry rifle.

Colonel Malet exhibits a model of a heavy gun on a carriage, slung on arms, so as to admit of its recoiling with a pendulum motion and with a hydraulic buffer. Another gun is slung by its trunnions, the breech being hung from its elevating gear. There is a Jones revolving duplicate shield of plate iron for ports or embrasures. An army entrenching tool, combining pick and spade, is exhibited by Storey. A model of a breech-loading system is shown by Bayly. A case of sporting rifles, revolvers, duck guns, and harpoon guns, are shown by Bland, of the Strand and Birmingham.

Patstone of Southampton, and Parkes, also show cases of sporting arms.

Turner, of Brook-street, in his case of sporting guns, has a special article that deserves notice, namely, an attachable muzzle. This consists of a few inches of rifled or smooth-bore barrel, which is attached on prolongation of an arm either to alter the shooting powers of a smooth bore or to rifle the piece. It is stated that these few inches of barrel, when grooved, are sufficient for this purpose, and that the bullet does not strip. The entire value depends on what is actually shown to be done. We should not have expected good rifle shooting from it, but should be quite ready to admit its value if well established by practice. Gilbert has a shield for fixing on the left side of a barrel of a small-arm rifle, so as to prevent the left eye from seeing the barrel and sight. It is therefore impossible for the shooting to be affected by unconscious use of the left eye, to which the inventor attributes much of the bad shooting now complained of.

Sporting guns and revolvers are shown by Gye and Moncrieff, of Dover-street. There is a very neat breech-loader, of which the lock is placed in a moving breech-piece. The parts of the lock work horizontally, and are held very neatly inside the block, which can be removed by hand in an instant.

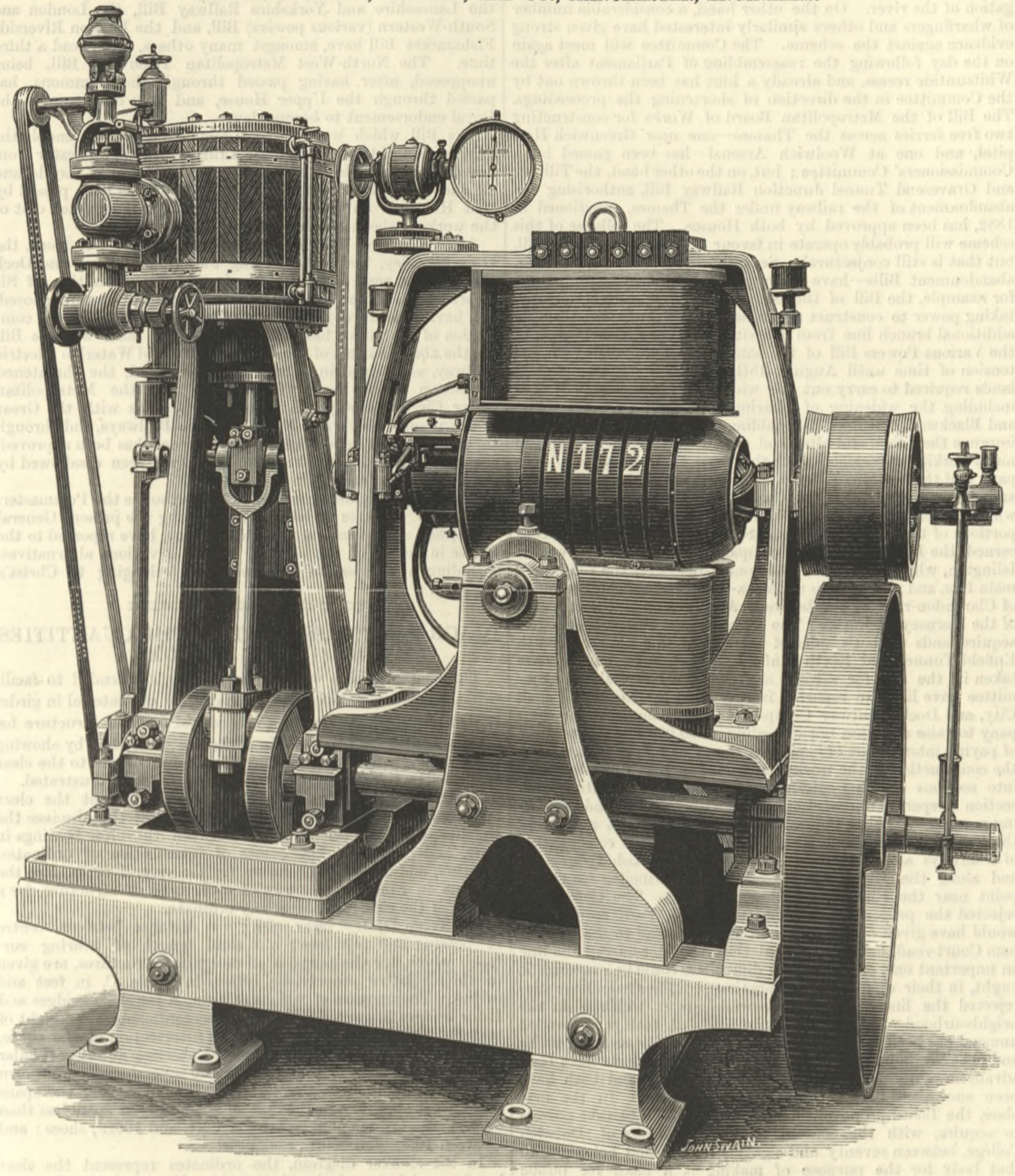
STEAM ENGINES AT THE INVENTIONS EXHIBITION.

No. II.

The display of steam engines at the Exhibition is, on the whole disappointing. The engines are few in number, and novelty of design is conspicuous by its absence. We have already at length referred to, and illustrated several. The remainder we shall deal with in due time. There is, however, so little to be said about engines alone that we include under the heading of this article air compressing machinery as well. A notable example of this is exhibited in the principal gallery by Messrs. Walker Brothers, of Wigan. This consists of a large pair of engines and compressors intended to supply motive power for Mr. Rammel's railway in the grounds. Messrs. Walker are ready, but the railway is not, so it would be premature to speak of it. There are some very novel features about the air compressors, which, however, cannot be made intelligible without drawings, which we shall give in an early impression. Meanwhile, we would direct attention to Messrs. Walker's stand, as one which will be found full of interest by engineers. We may add that the firm has recently published a catalogue, which contains very fine illustrations of nearly every possible form of plant that can be wanted in connection with mining. It is scarcely necessary to add that the reputation possessed by the firm is a guarantee of

INVENTIONS EXHIBITION—COMBINED ENGINE AND DYNAMO.

MESSRS. BROWETT, LINDLEY, AND CO., MANCHESTER, ENGINEERS.



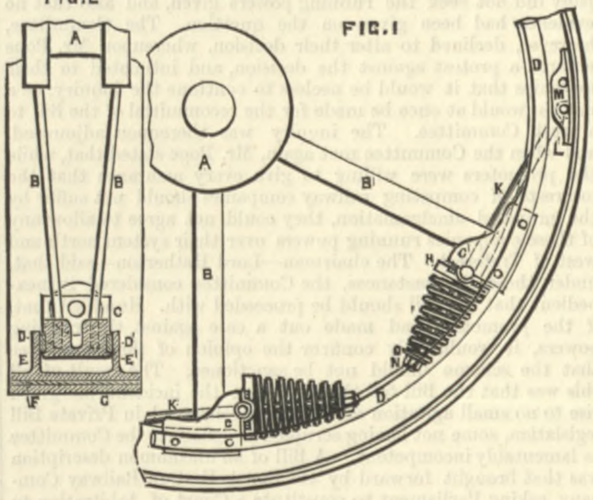
the excellence of the machinery illustrated. It is very far in advance of the ordinary trade catalogue, and we would gladly see the volume on the shelves of every young mining engineer.

In the grounds of the Inventions Exhibition, between the Main Hall and the Natural History Museum, is a compressed air tramway locomotive, on Mekarski's system. This locomotive is charged with compressed air at 30 atmospheres, or 450 lb. pressure, by machinery manufactured and exhibited by the General Engine and Boiler Company, Hatcham Ironworks, London, which has for ten years past made high-pressure air compressors a speciality. We illustrate the machinery exhibited on page 405, and may remark that it offers a very neat example of an air compressing installation. The air compressors are two, combined on the same bed-plate, and capable of being worked either together or separately. Each compressor is designed to deliver 50 cubic feet of air per hour at 450 lb. pressure, but on trial the reservoirs carried by the compressed air locomotive, of a capacity of about 120 cubic feet, were filled with air at 450 lb. in just over the hour. The compression is effected by two stages. A little water is introduced into the air cylinder with the air, and also a few drops of oil for lubrication. The air compressing cylinders are also surrounded with water, and the air after compression is cooled by being passed through a coil of pipe immersed in cold water. The air compressor is shown in front elevation, Fig. 1, in plan, Fig. 2, and in end elevation, Fig. 3. As it would be inconvenient on several accounts to allow the water admitted into the air compressing cylinder to find its way into the compressed air reservoir, a special separator column, shown at Figs. 1 and 3, and in section Fig. 4, is provided, by means of which the injection water is separated from the compressed air and drawn off from it, and the compressed air discharged into the reservoir in the dry state. The separator column is about 9ft. high altogether, and is composed of a steel tube 6½in. diameter. The air from the compressor enters the separator column by the pipe A, the water falls to the bottom of the vessel and is drained off at B. The dry air rises and passes off by the orifices C C either to the car reservoir direct or to the station reservoir, as may be required. No station reservoir is employed at the Inventions Exhibition, as the installation is not intended to be permanent.

The air compressor is driven by one of the General Engine and Boiler Company's well known "Express" engines coupled direct to the compressor. The apparent disproportion between the engine shaft and the compressor shaft is due partly to the fact that the latter is of steel, but mainly to the circumstance that the engine was taken from stock, and its crank shaft is strong enough for a steam pressure of 100 lb., although at the Exhibition only about 40 lb. is required to come upon the piston. Nor is this pressure always obtainable. Fig. 5 shows the cylinder in horizontal section, and Fig. 6 in vertical section. A novel feature about the engine is its patent governor—the simplest form of governor we ever recollect seeing. It is formed, as will be seen from Fig. 7, of a piece of ordinary chain kept strained in a straight line by means of a spring on the governor spindle when the engine is at rest, but which chains fly outwards and assume a curved shape under the action of centrifugal force when the engine is running.

Among the small engines may be mentioned a well designed and well finished pair by Messrs. Shanks, of Arbroath. These engines are so well known that description is unnecessary. Messrs. Duncan Brothers, Queen

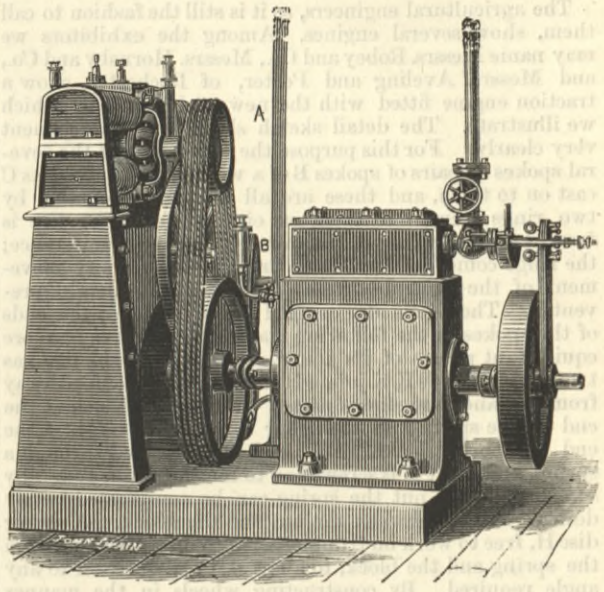
FIG. 2 FIG. I



MESSRS. AVELING AND PORTER'S SPRING WHEEL.

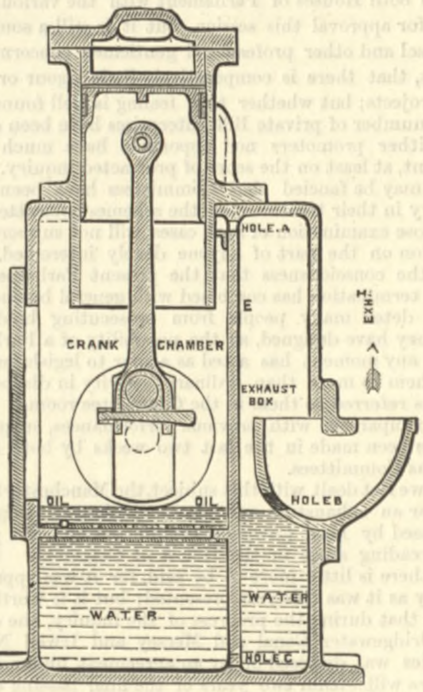
Victoria-street, show a launch engine, very similar to that illustrated on page 70, fitted with Bremmes' patent valve gear, and a pair of small launch engines fitted with Duncan's patent reversing gear. In this engine the slide valves work on an intermediate plate with crossed ports. This valve is actuated by the reversing lever, and according to the position in which it is placed, the engines go ahead or astern. This is decidedly the neatest arrangement for steam launch work we have seen. The engines can be handled with full steam on with the utmost facility, and their simplicity is in their favour, as there is no link motion or complication of any kind.

Not far from these engines will be found the stand of Messrs. Browett, Lindley, and Co., late Deacon and Parker, where will be found a vertical compound, and the engine and dynamo combined, which we illustrate. The engine has a 6in. cylinder and 8in. stroke. The dynamo is mounted on a swinging frame, as may be seen from our illustration. The heaviest end of this is next the fly-wheel of the engine, and is supported by the pulley of the dynamo resting on the fly-wheel. The pulley consists of discs of paper compressed between two iron discs, and is caused to revolve at 800 revolutions per minute while the engine makes about 150. In order to increase the adhesion there are two light rods—shown in our illustration—which unite two brass bearings, one on the dynamo spindle and the other on the crank shaft, and by turning two hand nuts screwed on the rods, the pulley can be forced down on the wheel and more adhesion obtained. This arrangement runs very well indeed. Of course, we can say nothing concerning the durability of the paper, but there is reason to think that no trouble will be caused from its wearing out with undue rapidity.



CHANDLER'S ENGINE AND ROPE DRIVING GEAR.

Messrs. Bumstead show in the South Gallery a small high-speed engine—Chandler's patent—driving a Phœnix dynamo by rope gear at 1500 revolutions, in a very ingenious and apparently satisfactory manner, the engine making 750 revolutions per minute. The dynamo is at a most convenient height for cleaning, &c.; it is supported upon a strong cast iron table. This method greatly economises floor space when it is not desirable to run an engine at too high a speed. At the back of and bolted on the base plate is a standard A, 5ft. to 6ft. high, upon which a tension wheel B may be moved for tightening the driving rope; this can easily be effected while working. This



SECTION OF CHANDLER'S ENGINE

arrangement is the joint idea of Professors Fleeming Jenkin and J. A. Ewing and Mr. Chandler. The governors of this engine claim special notice. All stuffing boxes leak more or less when subjected to considerable pressure. A basin is formed under the stuffing-box of the governors which catches any drops of condensed steam that may leak through; this basin forms part of the governor casting through which the spindle passes. At the level of the spindle a small pipe carries away water to prevent the basin from overflowing, thus water is kept at a constant level. On the top of this water floats oil, which automatically lubricates the governors and spindle which passes through the gland or stuffing-box. The small pipe allows water to pass away from the basin when sufficiently full, but in such a manner that the oil is retained floating in the basin. This is on a similar principle to that employed to retain the lubricant inside the engine crank chamber, and for which Mr. Chandler has a patent. The gland of these governors is screwed up by one nut, and it cannot pinch or jam the spindle, as is often done by careless attendants, for the gland is forced in by a small lever which takes its bearing equally on either side the governor spindle.

It should be noticed that there are no expensive lubricators of any kind employed on this engine; there is a simple oil-cup, which may be termed a measure in this case, for supplying oil to the engine at any time; this little cup if filled once a day will, it is stated, supply sufficient oil to the crank chamber for a ten or twelve hours' run. The accompanying engravings show the method of retaining the lubricant inside the engine. The bed or box is divided by a partition E, on one side of which are the crank-shaft connecting rods, &c.; by the rapid movement of these parts the oil is splashed to every part of the engine. D are plates perforated with small holes; these prevent the undue mixing of the oil and water, and thus effectually retain the oil floating inside the crank chamber. The small hole C allows water only to pass out into the exhaust box; thus the level in the boxes is the same. At B there is a small hole which allows water to pass into the exhaust pipe casting, and the exhaust steam carries this water away, and thus maintains a constant and uniform level in the crank chamber. As the cylinders are lubricated from the under side, the walls of the cylinders are thoroughly oiled, and the oil does not pass off with the steam, as is the case when the steam is lubricated.

The agricultural engineers, as it is still the fashion to call them, show several engines. Among the exhibitors we may name Messrs. Robey and Co., Messrs. Hornsby and Co., and Messrs. Aveling and Porter, of Rochester, show a traction engine fitted with the new spring wheels which we illustrate. The detail sketch shows the arrangement very clearly. For this purpose the outer ends of the several spokes or pairs of spokes B of a wheel have iron blocks C cast on to them, and these are all connected together by two rings secured to them on either side. The tire is formed with two flanges E E around its inner circumference; the rings come between these flanges, and sideway movement of the central portion of the wheel is thereby prevented. The tire is also coupled to the blocks at the ends of the spokes in the following manner:—At three or more equidistant points of its inner circumference the tire has two coupling rods K K jointed to it. These are inclined away from one another; one is passed through the block at the end of one spoke, and the other through the block at the end of another spoke. Each rod is also passed through a spring, and a nut N is screwed on to the end of the rod. By screwing up the nut the spring can be compressed to any desired extent between the nut and the block. A cap or disc H, free to work on trunnions, is also interposed between the spring and the block, to allow it to adapt itself to any angle required. By constructing wheels in the manner above described, the springs interposed between the spokes and the tire are always in compression, and they serve not only to give an elastic support to the load on the wheel, but also, when the wheels are used as the driving wheels of road locomotives, the tractive power of the engine passes through them, whereby shocks are avoided, both at starting and during work. The engine shown has wheels 7ft. high. These wheels have now run seven thousand miles, and have been run over balks of timber 8in. or 9in. high. These wheels have been adopted by the Government.

PRIVATE BILL LEGISLATION.

DURING the last fortnight considerable progress has been made in both Houses of Parliament with the various Bills submitted for approval this session, but it is still a source of grief to counsel and other professional gentlemen concerned in these schemes, that there is comparatively little vigour or vitality in these projects; but whether that feeling is well founded or not, a large number of private Bill enterprises have been dealt with, and neither promoters nor opponents have much ground of complaint, at least on the score of protracted inquiry. In a few cases it may be fancied that Committees have been somewhat summary in their treatment of the schemes submitted to them, but a close examination of such cases will not support any such suggestion on the part of anyone deeply interested. In fact, just as the consciousness that the present Parliament is very near its termination has combined with general business depression to deter many people from prosecuting bold ventures which they have designed, so the possibility of a Parliamentary crisis at any moment has acted as a spur to legislators, and impelled them to more than ordinary activity in disposing of the problems referred to them in the Committee rooms. Thus it is that in comparison with previous performances, surprising progress has been made in the last two weeks by both Lords and Commons Committees.

Since we last dealt with this subject, the Manchester Ship Canal Bill, after an exhaustive and almost tedious investigation, has been passed by Lord Cowper's Committee, and has passed the second reading stage in the House of Commons. Upon this project there is little more to be said, for it was approved substantially as it was this year presented; but it is worth while to mention that during the progress of the inquiry, the opposition of the Bridgewater Canal and Mersey and Irwell Navigation Companies was disposed of by an agreement under which the promoters will within two years of the final passing of the Bill purchase both these undertakings for the sum of £1,710,000. Speaking broadly, the opposition to this measure in its modified form this year has been feeble, and there are few people who do not anticipate that the Bill will, after Whitsuntide, pass successfully through the Lower House. Among the respective parties there is a good deal of speculation as to who will be the chairman of the Commons Committee, and it is urged that as the chairmen of the two Committees which have already considered the scheme, viz., Sir Joseph Bailey and Mr. Sclater-Booth, are members of the opposition, the chairman of the next Committee should in fairness be a Liberal, and it is likely that Mr. W. E. Forster will be chosen.

The Bill promoted by the Corporation of London to authorise the construction of the low-level bridge across the Thames, to which we have more than once referred, has engaged the attention of a committee of the House of Commons for something like three weeks already. This investigation promises to rival the ship canal inquiry in point of time, for the Bill is opposed by a formidable contingent, among the original petitioners being the General Steam Navigation Company, the Thames Conservators, the Tower Subway Company, the Steamship Owners' Association, the Traffic Committee of Billingsgate, St. Olave's District Board of Works, the Metropolitan Railway Company, Messrs. Courage and Co., Messrs. Besleys and Wilson, the London and St. Katherine's Docks Company, Messrs. Beresford and Co., Messrs. John Knill and Co., the promoters of the Tower Floating Bridge, the New River Company, as well as various persons, such as the owners of quays and warehouses. So far a strong case has been made out in favour of the scheme, the witnesses including not only people anxious to have additional means of crossing the Thames below London Bridge, but a number of pilots and other nautical authorities qualified to speak as to the probable effect of the bridge upon the navigation of the river. On the other hand, a considerable number of wharfingers and others similarly interested have given strong evidence against the scheme. The Committee will meet again on the day following the reassembling of Parliament after the Whitsuntide recess, and already a hint has been thrown out by the Committee in the direction of shortening the proceedings. The Bill of the Metropolitan Board of Works for constructing two free ferries across the Thames—one near Greenwich Hospital, and one at Woolwich Arsenal—has been passed by a Commissioners' Committee; but, on the other hand, the Tilbury and Gravesend Tunnel Junction Railway Bill, authorising the abandonment of the railway under the Thames, sanctioned in 1882, has been approved by both Houses. The collapse of this scheme will probably operate in favour of the Tower Bridge Bill, but that is still conjectural. Several other Bills—not, however, abandonment Bills—have been passed by Select Committees; for example, the Bill of the South-Eastern Railway Company, taking power to construct a new harbour at Folkestone and an additional branch line from Cheriton to Folkestone harbour; the Various Powers Bill of the same company, granting an extension of time until August 18th, 1887, for the purchase of lands required to carry out the widenings authorised in 1882—including the widening of Charing-cross Bridge; the London and Blackwall Railway Bill, enabling the company to widen and improve their line, and alter and extend various bridges, and to make working agreements with the Great Eastern Railway Company and the London, Tilbury, and Southend Railway Company; and the Omnibus Bill of the Great Northern Railway Company, which confers twenty-four distinct powers in respect of various portions of the company's lines. So far as the metropolis is concerned, the Bill empowers the company to widen the archway at Islington, which carries the Caledonian-road over the company's main line, and also to stop up Alma-road, Hornsey, and so much of Clarendon-road as lies between Alma-road and the property of the Hornsey gasworks. The company are also authorised to acquire lands on both sides of their main line between South Enfield Tunnel and North Enfield Tunnel, but no powers are taken in the Bill for raising any additional capital. A Committee have likewise reported in favour of the Regent's Canal, City, and Docks Railway Company's Bill, authorising the company to raise any sum not exceeding £660,000 for the purpose of paying interest out of capital at the rate of 4 per cent. during the construction of the works sanctioned in 1882; and to divide into sections the line originally sanctioned, constituting each section a separate undertaking with distinct capital and borrowing powers. Another Committee have passed that portion of the London Street Tramways Bill, authorising the construction of tramways along Fleet-road, Hampstead, Kentish Town-road, and along the King's Cross-road, and Farringdon-road, to a point near the Clerkenwell Sessions-house. The Committee rejected the proposed line along the Chalk Farm-road, which would have given direct access from Hampstead to the Tottenham Court-road, but they stated that they considered the line an important one, and if certain difficulties could be overcome it ought, in their opinion, to be sanctioned. The Committee also rejected the line along the Crowndale-road, which is in the neighbourhood of the Chalk Farm-road. A feature somewhat unusual has been the promotion of schemes for securing parks and open grounds for the people. Two such projects have been advanced by the Metropolitan Board of Works, and both have been successful before Commons Committees. In the first place, the Board proposed, in an Omnibus Bill, to take powers to acquire, with the consent of the Governors of Dulwich College, between seventy and eighty acres of land belonging to that body for the purpose of making it a place for public recreation; and in the next place, they obtained authority to purchase for £60,000 the whole of Highbury-fields, comprising about sixty acres of land, and to keep the land for ever open for the public.

For the most part, the proceedings of these various Committees have been devoid of any circumstance specially worth noting, but a singular incident occurred in connection with a Bill under consideration by the House of Lords Committee, to empower the Marquis of Bute to sell the whole of his docks at Cardiff to the Taff Vale Railway Company for the sum of £3,200,000. The Committee decided to allow the Bill to proceed, subject to the insertion of a clause giving the Barry Dock and Railway Company—which is a competing dock sanctioned last session—running powers over the greater part of the Taff Vale Railway, together with the insertion of clauses for the protection of other railway companies. Upon this decision being given, Mr. Pope, Q.C., on behalf of the Marquis of Bute and the Taff Vale Railway Company, pointed out that the Barry Company did not seek the running powers given, and also that no evidence had been given on the question. The Committee, however, declined to alter their decision, whereupon Mr. Pope entered a protest against the decision, and intimated to their lordships that it would be useless to continue the inquiry, as a motion would at once be made for the recommittal of the Bill to a fresh Committee. The inquiry was thereupon adjourned, and when the Committee met again, Mr. Pope stated that, while the promoters were willing to give every assurance that the interests of competing railway companies should not suffer by the proposed amalgamation, they could not agree to allow any of these companies running powers over their system north and west of Treforest. The chairman—Lord Hatherton—said that, under these circumstances, the Committee considered it inexpedient that the Bill should be proceeded with. He added that, if the promoters had made out a case against the running powers, it would only confirm the opinion of the Committee that the scheme should not be sanctioned. The result of all this was that the Bill fell through; but the incident has given rise to no small agitation among those concerned in Private Bill legislation, some not having scrupled to denounce the Committee as lamentably incompetent. A Bill of an uncommon description was that brought forward by the South-Eastern Railway Company, asking Parliament to constitute a Court of Arbitration to settle all questions in dispute between the company and the London, Chatham, and Dover Company. To that proposal the last-named company objected, on the ground that, while a competent tribunal like the courts of law existed, Parliament had no power to compel two companies to arbitrate if one declined to take that course; and upon that contention a House of Lords Committee rejected the Bill. A number of ordinary provincial Bills have been before Select Committees of one or other House, but none of them calls for special mention. The Bill for continuing the experimental works in connection with the Channel Tunnel scheme again came before the House of Commons, on a motion by Sir Edward Watkin to read it a second time. It was, however, opposed by Mr. Chamberlain, as the mouthpiece of the Government, and eventually rejected by 281 votes to 99.

Besides the results recorded above, the Metropolitan Streets Act (1867) Extension Bill, the East and West India Dock Company Bill, and the Liverpool and Birkenhead Subway Bill have passed the third reading in the House of Lords; while in the House of Commons the Great Northern (various powers) Bill, the Lancashire and Yorkshire Railway Bill, the London and South-Western (various powers) Bill, and the London Riverside Fishmarket Bill have, amongst many others, been read a third time. The North-West Metropolitan Tramways Bill, being unopposed, after having passed through the Commons, has passed through the Upper House, and now only awaits the Royal endorsement to become law.

The Bill which we described some time ago to enable the Corporation of Glasgow to draw a further supply of water from Loch Katrine has been brought up in the House of Lords, and all the opposition having been removed, it has been passed by that House as an unopposed measure. The estimated cost of the works is about one million.

After a rather lively debate in the House of Commons, the Hull, Barnsley, and West Riding Junction Railway and Dock Bill has been read a third time, despite the opposition of Sir Robert Peel. The Limehouse Subway Bill, being unopposed, and having for its object the extension of the time for the completion of the works, has passed, and in the same way the Bill for the abandonment of the Charing-cross and Waterloo Electric Railway, sanctioned in 1882, has been passed, the threatened opposition having been withdrawn. Also the Metropolitan Outer Circle Railway Bill, to effect junctions with the Great Western and London and North-Western Railways, and through them with the systems south of the Thames, has been approved, the only opposition to the scheme having been disallowed by the Court of Referees.

The Select Committee on the Bill to authorise the Postmaster-General to purchase various sites adjoining the present General Post-office, and in certain provincial towns, have reported to the House in favour of the scheme, rejecting various alternatives, including a proposal to acquire a site belonging to Christ's Hospital.

DIAGRAMS FOR ESTIMATING THE QUANTITIES OF GIRDER BRIDGES.

THE diagram which we publish this day is intended to facilitate the rapid calculation of the quantities of material in girder bridges, to illustrate the most economical form of structure for different spans, and to assist in designing the same by showing the different proportions of the several dimensions to the clear span for the thirteen types of girder construction illustrated.

In the larger diagram, the ordinates represent the clear bearing $l = L + 2a$ in feet—see Table G—and the abscissæ the weights of girder per foot run between the clear bearings in cwts. and quarters. The points of intersection of ordinates, abscissæ, and the different curves for the several types, give the weights in iron per foot run of each type of structure, for a bridge of the clear bearing of any ordinate.

For Table G, L = clear span; a = distance between centre of bearing and pier face; b = total length of bearing surface; which, for the purpose of designing structures, are given in their relative proportions below, in Table C, in feet and inches. The increase of weight of iron, A for skew bridges and B for bridges in curves, is given in percentage of the weight of material obtained from the point of intersection of the curve, representing the type adopted and the abscissæ at any particular span. The weights of bed-plate for the several spans are shown by the weights in cwts. above a thick line indicating the spans to which it applies. In the case of bridges of a span less than 60ft., plates are adopted; between 60ft. and 100ft., shoes; and between 100ft. and 300ft., rocking shoes.

In the smaller diagram, the ordinates represent the clear bearing and feet, and the abscissæ the distance in feet between the centres of girders for the several types of bridges, at the point of intersection with the curves representing any particular span. It will be seen from the above, as far as weight is concerned, irrespective of labour, that for the following spans the most economical structures are:—Up to 40ft. span, plate girders, types 1 and 2, or framed girders, type 5; from 40ft. to 100ft., framed girders, type 7; from 100ft. to 210ft., arched girders, type 9; from 210ft. to 300ft., bowstring girders, type 13. The diagrams are compiled on the types and calculations adopted by and from data obtained from the General Inspection of Austrian Railways.

TENDERS.

PENRHYNDEUDRAETH.

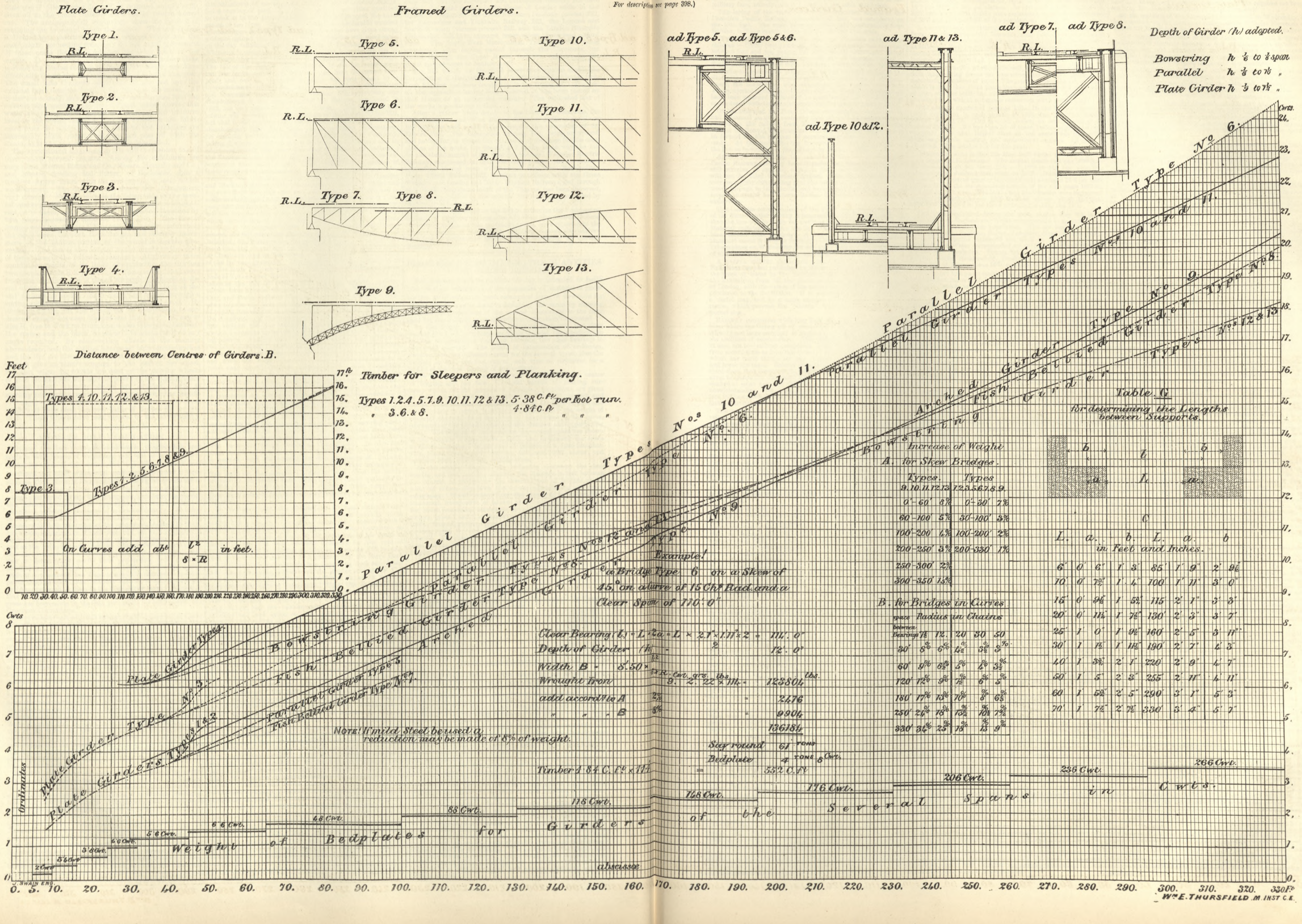
FOR main sewerage and works connected therewith. Mr. Thomas Roberts, Assoc. M. Inst. C.E., engineer.

	£	s.	d.
White and Owens, Aberystwith	1696	14	0
Griffiths, Criccieth	1368	18	6
Mathews, Criccieth	1327	0	0
Owen, Portmadoc	1284	0	0
Thomas, Bangor	1281	5	0
Davies, Portmadoc—accepted	1240	0	0
Engineer's estimate	1381	16	4

THE TIN CAN'S MISSION.—The empty tin can at last has a mission, and a profitable one at that. Emptied of its contents of peaches or tomatoes, discarded and thrown out at the kitchen gate, it may soon be sent in at the front door or find an honoured place in the best room in the house. Thousands of these cans are gathered in Philadelphia every week and made into shining sheets and used to decorate or cover travelling trunks, and thus get a promotion from the back yard to the boudoir. On the outskirts of the city, within a short time, a number of factories for the conversion of these old buffeted and battered cans and other tin refuse from the ash heaps have sprung up, and the business is a growing one. One of considerable size is in the Moyamensing-avenue, below Mifflin-street, where a large force of men is kept busy day in and day out. The cans are collected in various ways, but principally from the city ash heaps and the hotels and large boarding-houses. At the factory the soldered seams are subjected to an intense heat in such a way that the solder is allowed to run into a receptacle, and is carefully saved and sold, the profit from this source alone almost paying for the expense of the gathering and handling of the cans. The tops and bottoms of the cans are melted and turned into window-sash weights. The labels on the tin plates are easily taken off, after they have been thoroughly soaked in water, and the plates themselves rolled out flat by machinery. As the insides of the plates are not much discoloured by the contents of the can, they present a clean surface and make excellent covers for trunks, the seams being hidden by the trunk braces, either of wood or sheet iron. Other uses are also made of the tin plates, and there is considerable profit in the business. The process is quite simple, and very little capital is required. One concern in this city rolled out 40,000 of these plates in less than two months, and the industry promises to be largely developed both here and elsewhere.—*Philadelphia Record.*

AUSTRIAN RAILWAY DIAGRAMS FOR ESTIMATING THE QUANTITIES OF GIRDER BRIDGES.

(For description see page 398.)



RAILWAY MATTERS.

THE fare for children in numbers, as in school *fêtes*, on the Prussian State railways will next summer be the same as the military fare, namely, about a farthing per mile, third-class.

THE laying of the track on the last unfinished section of the Canadian Pacific Railway, near Jackfish Bay, was completed on the 18th inst. The rails have now been laid continuously from Halifax, in Nova Scotia, to the coast of British Columbia.

THE following are in future the fares on Prussian railways for children:—Under four years old, free, when a seat is not required; between four and ten years, half fare, for all classes and trains, and an allowance of 12 kilograms—26½ lb.—of baggage, instead of the 25 kilograms allowed for a full fare; above 10 years, full fare.

IT affords considerable satisfaction to find that the claims of the St. Gothard Railway Company against the executors of M. Louis Favre, the contractor, who constructed the tunnel, have been wholly rejected by the Berne Courts, while M. Favre's representatives have been awarded 1,750,000f. in consideration of the difficulties encountered with the plastic strata and for general contingencies.

ON the 16th inst. the *Times* Odessa correspondent wrote that he had "learned on good authority that no work is now being performed on the railway from Kizil Arvat to Askabad, probably because the Second Transcaspian Railway Battalion, which was to be formed for the purpose of constructing that line, is not yet ready. At the same time the Imperial order has been given for the line to be completed throughout by March 1, 1886."

ALTHOUGH the gap in the continuous line of the Canadian Pacific Railway north of Lake Superior has been filled in, there still remains, it appears, a gap in the Rocky Mountains which will not be filled in before August. This latter gap is, however, so rapidly diminishing that the company have offered to take troops through to the Pacific, and have actually arranged to carry torpedo material to Victoria, British Columbia, for the Imperial authorities.

THE Calcutta correspondent of the *Times* says, the construction of the trans-frontier railway is progressing rapidly. It is expected that the line will be ready for traffic as far as Mutch in sixty days. Material sufficient to carry the line to Candahar, if necessary, has been ordered from England. A large quantity of supplies and transport stores is lying at Suakim ready to be transferred to India. Telegraphing on Wednesday, he said there is no sign of a relaxation of the military preparations in this country.

A USEFUL railway guide and route book to the Inventions Exhibition has been published by Messrs. Clowes and Sons, giving the times of trains to the Exhibition, and the latest trains from the Exhibition, from all the places within a considerable distance of London, with the names of the railways and the fares, including admission to the Exhibition. It is accompanied by an index and a useful map, and by a large number of unnecessary advertisements, which prevent the "Guide" from being of a convenient pocket size.

RAILWAY companies with long lines are troubled with the problem which the falling off of second-class traffic is causing them. Already one large company is beginning to follow the Midland in the abolition of second-class. This cannot be done on local lines. It need not be—railway companies might make as good a harvest from second-class as from third-class if they would adopt the policy which has made third-class pay—namely, improve the carriages and lower the fares. Second-class fares are so much higher than third-class, that the many thousands who would gladly pay a little extra to escape the disagreeables of the company of the great unwashed at some hours of the day, are driven into the third-class notwithstanding. On most lines the jump from the third-class fare to the second-class is so great that the failure of the second-class is inevitable.

THE much discussed trial of electric locomotion on the elevated railroads in New York is to be undertaken on two different lines, and on each a distinct system will be put in operation. A good opportunity for comparison will thus be furnished. The one undertaken on the Edison-Field plan consists in providing each car with its own motor, and thus making it independent of any train controlling locomotive. In carrying out this system each car will have two motors mounted respectively upon the trucks and belted to pulleys upon the axles of the car. The road will have an additional central rail, which will lead the current to the motors. The current will be picked up by two wheels, the two outer tracks constituting the return circuit. The *Electrical World* says the external appearance of the motor resembles that of machines of the Siemens type. It is difficult to see where the "system" lies in these American locomotives.

FROM the opening of the first section of the New York elevated railways for business, April 20th, 1871, to March 16th, 1885, these lines have carried passengers as follows:—Old West Side road, from April 20th to May 19th, 1871, 7242; Trustee from May 19th, 1871, to January 3rd, 1872, 75,697; present companies, from January 3rd, 1872, to March 16th, 1885, 521,427,391; total, 521,510,330. But one passenger has ever been killed upon these lines after being on board the cars, and he lost his life from his own negligence or carelessness. There is no parallel in the history of railway operation to this, as many passengers could not have passed over the same routes, or over any other like distance, on foot or in any other way, as safely. There is now in operation in the city of New York 80 miles single track elevated railroad, which has been built since 1874, the most of it in the years 1878, 1879, and 1880.

THE second part of the recently published Board of Trade Report on railway accidents during 1884 includes passengers and other persons not servants killed and wounded from accidents other than those already mentioned—such as accidents caused by want of caution or misconduct, accidents to persons trespassing or passing over level crossings, and others. Of the 557 persons killed and 917 injured in this division, 104 of the killed and 627 of the injured were passengers. These numbers show some diminution from those of 1883, when the returns gave 114 and 754 respectively. In getting into or alighting from carriages, 35 passengers were killed and 466 injured, either by falling between the carriages and platforms, or by falling on to platforms or ballast; 41 were killed and 22 injured in passing over the line at stations; 7 were killed and 30 injured by falls from trains while in motion; and 21 were killed and 61 injured from other causes. Of persons other than passengers and servants, 65 met their deaths and 27 received injuries while passing over railways at level crossings; 295 were killed and 187 injured when trespassing; 53 persons committed suicide; and of other persons, mostly private people having business on the companies' premises, but not specifically classed, 40 were killed and 76 injured.

A LETTER from Yale, British Columbia, says:—"A frightful accident occurred on the Western Division of the Canadian Pacific road, fifty miles above Yale, on the night of February 25th last, no account of which has hitherto been printed. An engine, drawing twenty lumber-laden cars and a caboose, was bowling rapidly down the winding track along the Fraser River. On one side were cliffs reaching to a height of 3000ft., occasionally cut through by frowning canons, spanned by high trestles. A huge boulder, loosened by the storm, had dropped from its heights at the entrance of one of these trestles, and Engineer Evans did not see it in time to prevent a collision. The engine, after striking the boulder, shot from the trestle, followed by the tender and four cars. The engine described a great arc, landing across the gorge 100ft. away, and then slipping 150ft. down the sloping granite wall to the brink of the river, where it stopped. Engineer Evans remained in the engine, and, strange to say, was uninjured, though both the cylinders were broken, and the engine otherwise badly wrecked. Fireman Gascoigne, who leaped from the tender down the side of the gorge, was seriously injured, though he is now fast recovering. The four lumber-laden cars were reduced to a mass of splinters on the rocks below, while ten passengers in the caboose in the rear, which remained on the track, were uninjured save a few bruises."

NOTES AND MEMORANDA.

IN Greater London 3148 births and 1821 deaths, during the week ending 9th May, were registered, equal to annual rates of 31·6 and 18·3 per 1000 of the population. In Greater London, last week, 3322 births and 1834 deaths were registered, equal to annual rates of 33·3 and 18·4 per 1000 of the population.

A GIGANTIC oak has recently been felled by Messrs. Ackroyd and Bros., of the Birkenshaw Sawmills, near Leeds. Its dimensions have rarely been exceeded in this country, the measurements being as follows:—First length 30ft., 16ft. circumference in the centre; second length 15ft., 12ft. circumference, containing, with the limbs, upwards of 800 cubic feet.

ACCORDING to Mr. Shelford Bidwell, nickel continues to retract with magnetising forces far exceeding those which produce the maximum elongation of iron. The greatest observed retraction of nickel is more than three times the maximum observed elongation of iron, and the limit has not yet been reached. A nickel wire stretched by a weight undergoes retraction when magnetised.

THE average number of persons killed in the United States by boiler explosions in each month of 1884 was 21. The number injured was 21·75. The saw-mill boiler, as usual, stood at the head of the list. No less than 56 of these boilers exploded during the year. The next largest class on the record was that which includes portable, hoisting, and agricultural engines. Of these 18 exploded. The total is 152 for the year.

DURING the week ending 9th May, 2429 births and 1465 deaths were registered in London. The annual death-rate per 1000 from all causes, which has been 22·3 and 19·8 in the two preceding weeks, further declined last week to 18·7. During the first five weeks of the current quarter the death-rate averaged 21·3 per 1000, against 22·8 in the corresponding periods of the nine years 1876-84. In London, last week, 2544 births and 1496 deaths were registered. The annual death-rate per 1000 from all causes, which had been 22·3, 19·8, and 18·7 in the three preceding weeks, was 19·1.

THE deaths registered during the week ending May 9th in 28 great towns of England and Wales corresponded to an annual rate of 20·2 per 1000 of their population. The six healthiest places were Plymouth, Brighton, Bolton, Leicester, Norwich, and Portsmouth. The deaths registered last week in 28 great towns of England and Wales corresponded to an annual rate of 20·4 per 1000 of their population. The six healthiest places were Brighton, Bolton. Derby, Huddersfield, Bradford, and Birmingham. The death-rate of Brighton was 10·9, and that of Birmingham 17·9

ACCORDING to a paper recently read before the Royal Society by Mr. Shelford Bidwell, M.A., magnetisation produces elongation in soft steel, which, as in the case of iron, increases up to a certain value of the magnetising force, and afterwards diminishes. The maximum elongation is less than in iron, and the rate of diminution after the maximum is passed is also less. The critical value of the magnetising force for a steel rod diminishes with increasing hardness up to a certain point, corresponding to a yellow temper, after which it increases, and with very hard steel becomes very high. There is therefore a critical degree of hardness, for which the critical magnetising force is a minimum. In steel of a yellow temper the value of the critical magnetising force is lower than in steel which is either softer or harder. In soft steel a strong magnetising force subsequently diminished may cause a greater temporary elongation than the diminished force is capable of producing if applied in the first place. A temporary elongation when once produced in soft steel may be maintained by a magnetising force which is itself too small to originate any perceptible elongation.

IT is well known that water under certain conditions will fall slightly below 32 deg. without becoming solid, but it is not very often seen. A correspondent, writing to the *Scientific American*, says:—"Three times during the winter I have seen water instantaneously converted into ice in a large tin pail partly filled with water. There was ice on the floor, cups partly filled with water held thick coverings of ice, but the water in the pail was as clear as crystal. Intending to dip a cupful, I accidentally struck the edge of the pail, and quick as a flash of light there shot from the sides of the pail toward the centre long, slender needles of ice, beautifully marked on their edges. These needles in a few seconds grew until the water for an inch or so below the surface was closely packed with these delicate shoots." The editor, in a comment on the communication, says, "The peculiar phenomenon of the spasmodic setting of crystals is well known and familiar to chemists. It is beautifully shown in microscopic crystallisation. Under the microscope the crystallic needles are plainly seen to shoot out like the arrow from a bow. In some species of fungus the same spasmodic effect is noticed in the development of the spores. Its cause probably lies in the power of the attraction of cohesion, which in this class of phenomena is a resisting power to a change of condition."

EXPERIMENTS recently made in America on the action of artesian well water on metals afford figures of some interest. Slips of sheet metal were used, about 1in. wide by 4in. long, and weighing from 6 to 8 grams, according to thickness, the surface being the same in each case. On being immersed in water from an artesian well, the different slips had lost the following amounts after twenty four hours' immersion: iron, 0·0112 gram; zinc, 0·0012 gram; copper, 0·0003 gram. Of two slips, one of iron and one of zinc, immersed in the same water containing the iron, which was shown by the blue colour imparted by the same to a mixture of ferric chloride and red prussiate of potassa, as well as by its discolouring of starch solution blued by iodine. Iron immersed for the same time in the same kind of water, after being boiled, lost only 0·0055 gram, while in distilled water under the same circumstances it lost 0·0025 gram, and in distilled water in which sulphate of lime had been dissolved it lost 0·0043 gram. Immersed in Lake Michigan water unboiled, the iron lost 0·0124 gram, and in Lake Michigan water boiled, 0·0031 gram. Iron immersed in distilled water in which sulphate of lime, bicarbonate of soda, and free carbonic acid were present, lost 0·0011 gram, and sulphurous acid was also formed in the water. These are but a few of the figures obtained during the experiments, but they suffice to show, among other facts, that in its natural condition the Lake Michigan water is scarcely less severe on iron than artesian well water, containing an especially large amount of solid constituents.

ACCORDING to a paper read last month before the Royal Society "On the Changes produced by Magnetisation in the Length of Rods of Iron, Steel, and Nickel," by Shelford Bidwell, M.A., the length of an iron rod is increased by magnetisation up to a certain critical value of the magnetising force, when a maximum elongation is reached. If the critical value of the magnetising force is exceeded the elongation is diminished until with a sufficiently powerful magnetising force the original length of the rod is unaffected, and, if the force is still further increased, the rod undergoes retraction. Shortly after the critical point is passed the elongation diminishes in proportion as the magnetising force increases. The greatest actual retraction hitherto observed was equal to about half the maximum elongation, but there was no indication of a limit, and a stronger magnetising force would have produced further retraction. The value of the external magnetising force corresponding to maximum elongation is for a given rod approximately equal to twice its value at the "turning point." The turning point in the magnetisation of an iron bar is reached when the temporary moment begins to increase less rapidly than the external magnetising force. The external force corresponding to the point of maximum elongation increases, when the quality of the iron is the same, with the diameter of the rod. So also does its value at the turning point. The amount of the maximum elongation appears to vary inversely as the square root of the diameter of the rod, when the quality of the iron is the same. The turning point, and therefore presumably the point of maximum elongation, occurs with a smaller magnetising force when the rod is stretched than when it is unstretched.

MISCELLANEA.

WE notice that for the great bridge across the Forth and for the new Tay Bridge, all the Staffordshire blue bricks required are being made by Mr. Joseph Hamblet, of West Bromwich.

AT the meeting of the Liverpool City Council on Wednesday, it was resolved, on the motion of Alderman Sir William Forwood, to oppose the Manchester Ship Canal Bill in the House of Commons.

THE Sanitary Institute of Great Britain will hold a Health Exhibition of sanitary apparatus and appliances and articles of domestic use and economy in the Floral Hall, Belgrave-gate, Leicester, from September 22nd to October 10th, 1885, in connection with the eighth autumn congress of the Institute.

THE laying of the submarine cable connecting Lloyd's signal station on the Fastnet rock with the mainland at Crookhaven was successfully accomplished on the 14th inst. Vessels which pass this station and wish to be reported can now be signalled and reported by telegraph direct from the signal station on the rock.

ALREADY more than 500 persons have, it is said, announced their intention to attend the Congress on Inland Navigation which will be opened in Brussels on the 24th instant. The programme includes (1) canals in general; (2) maritime canals; (3) non-maritime canals; and (4) technical subjects. Visits to the Belgian maritime canals are projected.

ON Saturday the Teddington Local Board issued a public notice inviting tenders for the erection of a suspension bridge over the river Thames at Teddington, and a lattice girder foot-bridge over the lock cut adjoining it, according to drawings and specifications prepared by Messrs. Pooley and Thompson, engineers. The project has been approved by the Thames Conservators.

THE *Times* Philadelphia correspondent says an important strike in the iron trade is impending at Pittsburg. The existing agreement on the subject of wages expires with May, and the ironmasters insist on new prices, at 20 per cent. reduction. Repeated conferences have failed to secure an agreement, and a strike is expected to occur on June 1, affecting some 50,000 workmen.

IT is officially announced that a competitive exhibition of water-raising engines, pumps, and machines, and air engines and machinery, including pumps, boring machinery, irrigating and other appliances, will be held at Lecce from 15th September to 15th October next. The costs of experiments will be paid by the Royal Office of Agriculture, Industry, and Commerce. Full particulars may be obtained from the Minister of Agriculture and Commerce, Signor B. Grimaldi, at Rome.

ON Wednesday, the Select Committee of the House of Commons on the Lower Thames Valley Main Sewerage Bill held their first meeting, to elect a chairman and to consider their course of procedure. Sir William Hart-Dyke was appointed to preside over the deliberations of the committee, and the next meeting will be held on June 8th, when the case for and against the scheme will be gone into. The Bill provides for the reconstitution of the authorities charged with disposal of the sewage of the Lower Thames Valley.

THE managers of the American Exhibition to be held in London in 1886 have succeeded in securing a location for their enterprise in Earl's Court:—The selected site is but a short distance from South Kensington, and situated in the best part of London. The property to be occupied by the Exhibition covers about twenty acres, and has railway advantages in advance of any Exhibition ever held in London. The station for the District Railway will be in the Exhibition grounds, and another one will be at West Brompton, a few steps from the entrance to the main building.

IN answer to a question on steel-wire guns, Mr. Brand said in the House on the 14th inst. that a howitzer of 10in. calibre and a gun of 9·2in. calibre, both partly constructed of steel wire, have been ordered for trial on the recommendation of the Ordnance Committee. The guns are being made under the orders of the responsible officers of the department, who are thoroughly acquainted with the principles involved. The gun apparently referred to by the hon. member in his third inquiry as having been made at Elswick is about of equal power with the 25-ton gun of the service. As regards future manufacture, this must entirely depend upon the results obtained in the experimental trials.

ACCORDING to the report to the Registrar-General by Dr. Frankland on the results of the chemical analyses of the waters supplied to the metropolis during April, the Thames water distributed by the Chelsea, West Middlesex, Southwark, Grand Junction, and Lambeth companies contained, in every case, less organic matter than in the previous month's samples. All the samples were clear and bright. The water drawn from the Lea and delivered by the New River and East London Companies also exhibited a considerable improvement as regards organic matter, the amount of the latter being less than in any of the Thames waters. Both waters were clear and bright on delivery. The fact that London water is really good is growing more evident even to Dr. Frankland.

ON Saturday the South Yorkshire Coalowners' Assurance Society, who own more than one half of the pits thrown idle, issued to the public a statement which may be taken as their manifesto. The coalowners strike a firm note. They stand decisively for a return of the 10 per cent. conceded in 1882. "They ask no more. They will take no less. The sooner any doubt on the point is dispelled, if doubt in fact there be, the better it will be for both owners and miners." Every day now there are men returning to work, the least hopeful locality being Denaby Main, which, however, it is only right to remember, has no connection with the present strike, the rupture at Denaby being caused by a new system of working which the employers desire to introduce, and which the men have not yet even tried.

MESSRS. DONALD CURRIE AND CO.'s steamship Garth Castle, Captain R. Duncan, and the P. and O. steamship Chusan, Captain H. Wyatt, arrived in Plymouth Sound on Tuesday within one hour and a-quarter of each other after an exciting race across the Bay of Biscay. It appears that after passing Cape Finisterre the Chusan sighted the Garth Castle steaming ahead of her. She at once put on all steam and raced up to the Garth Castle, and the two vessels then made a fair start for Plymouth. There was great excitement among the passengers on board the two ships and a large number of bets were made. The pair kept well together up to Sunday night, when the Garth Castle went ahead, arriving at the Eddystone forty-two minutes before the Chusan, and anchoring in the Sound one hour and a-quarter ahead of her. It was stated by some of the passengers that at one time the two vessels were so close to each other that bets were made between passengers of each ship. This must have been a lively time for engines and engineers and stokers.

ON Monday evening a paper was read at the Inventors' Institute "On Electric Tramcars," by Mr. A. Reckenzaun. This described a car worked by secondary batteries and the author's motors. For the car there are two motors, each capable of working up to nearly 9-horse power, and weighing 420 lb. Each motor is carried separately upon a small bogie, in such a way that each bogie forms a small locomotive engine, upon which the car rests. One axle of each bogie is a driving axle; thus are actuated four small driving wheels. The speed of the motors is high, about 1000 revolutions per minute when the car is running at seven miles an hour. The gearing employed is a worm on each motor shaft, and worm-wheels on the driving axles, giving a ratio of about 1 to 12. This worm gearing is encased, and the wheels work in oil, the lubrication being perfect. The variation of speed and power is obtained by means of a compound switch, which arranges the motor circuits so that the machines shall work in series, in parallel, or singly; thus the resistance of the circuit being varied, the power and speed vary accordingly. When a greater range of speed is desirable, the motor circuits are still further divided by arranging the field magnet wires apart from the armatures. This obviates cumbersome gearing.

THE INVENTIONS EXHIBITION—BUTLER'S MOVABLE COAL STAITHS.

(For description see page 402.)

FIG. 1

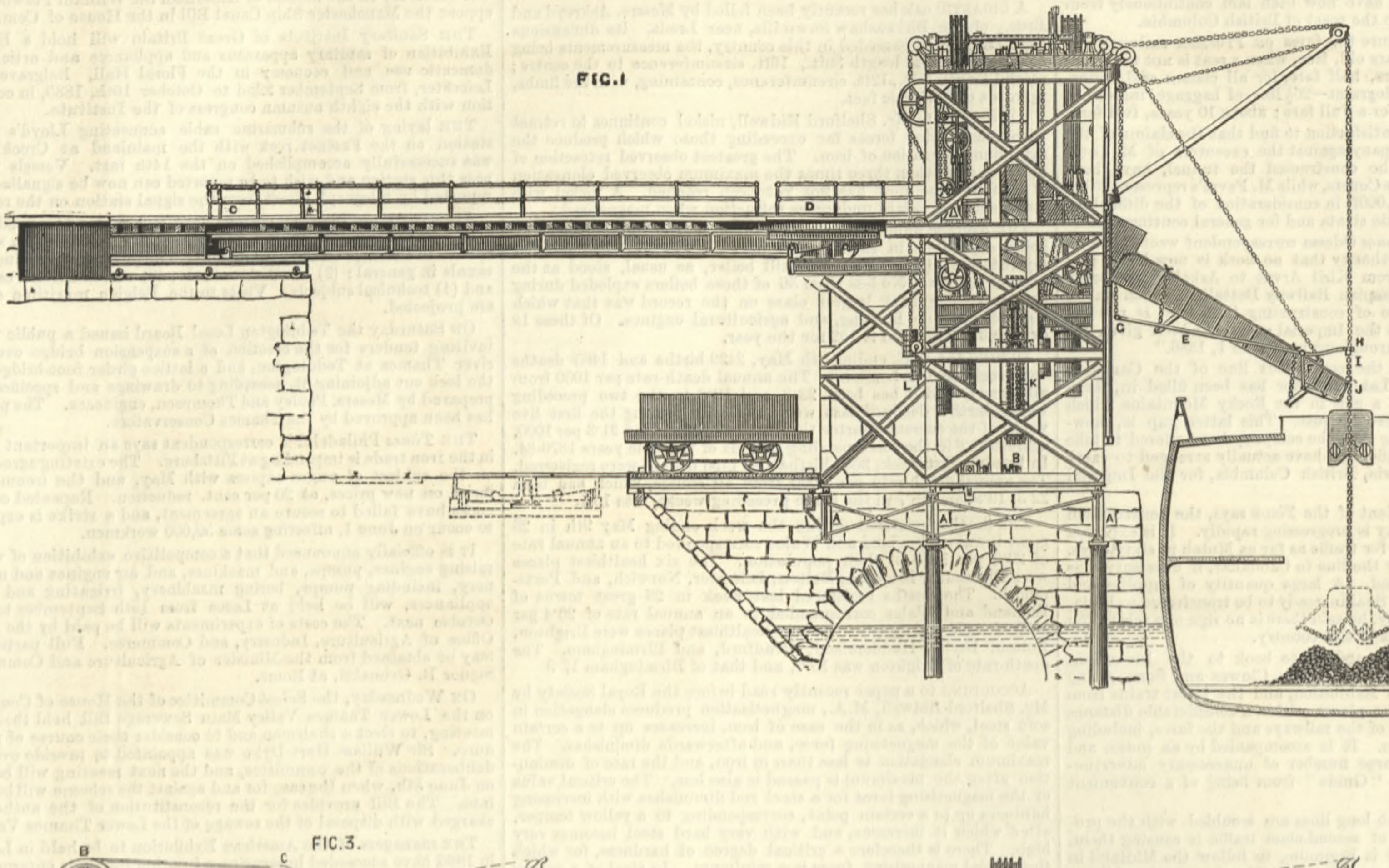


FIG. 3

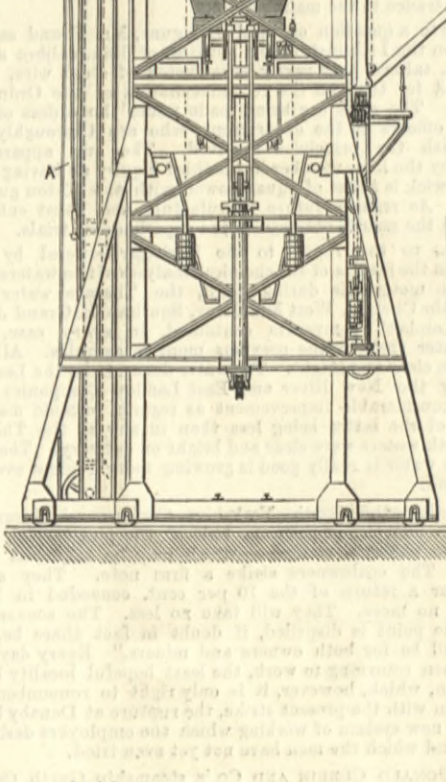


FIG. 4

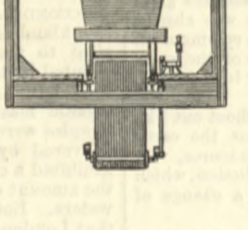


FIG. 5

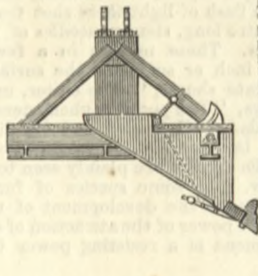


FIG. 6

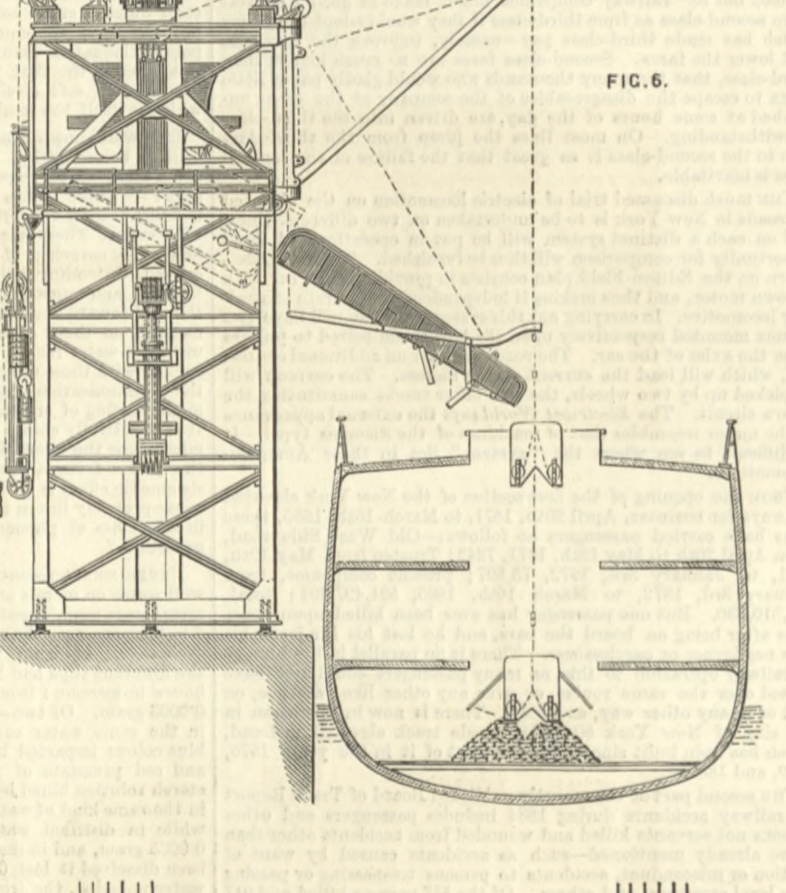
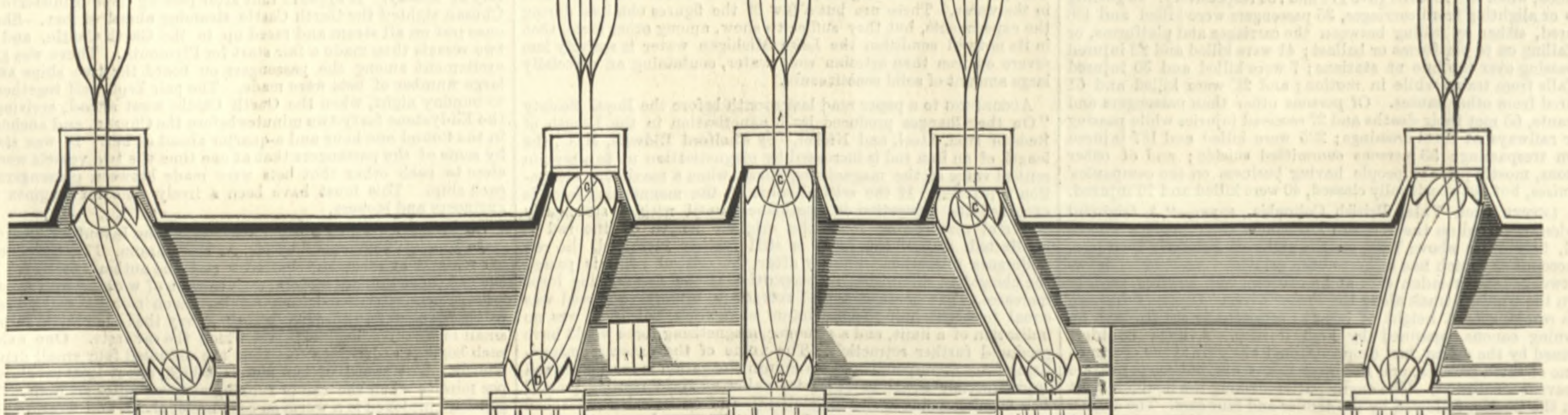


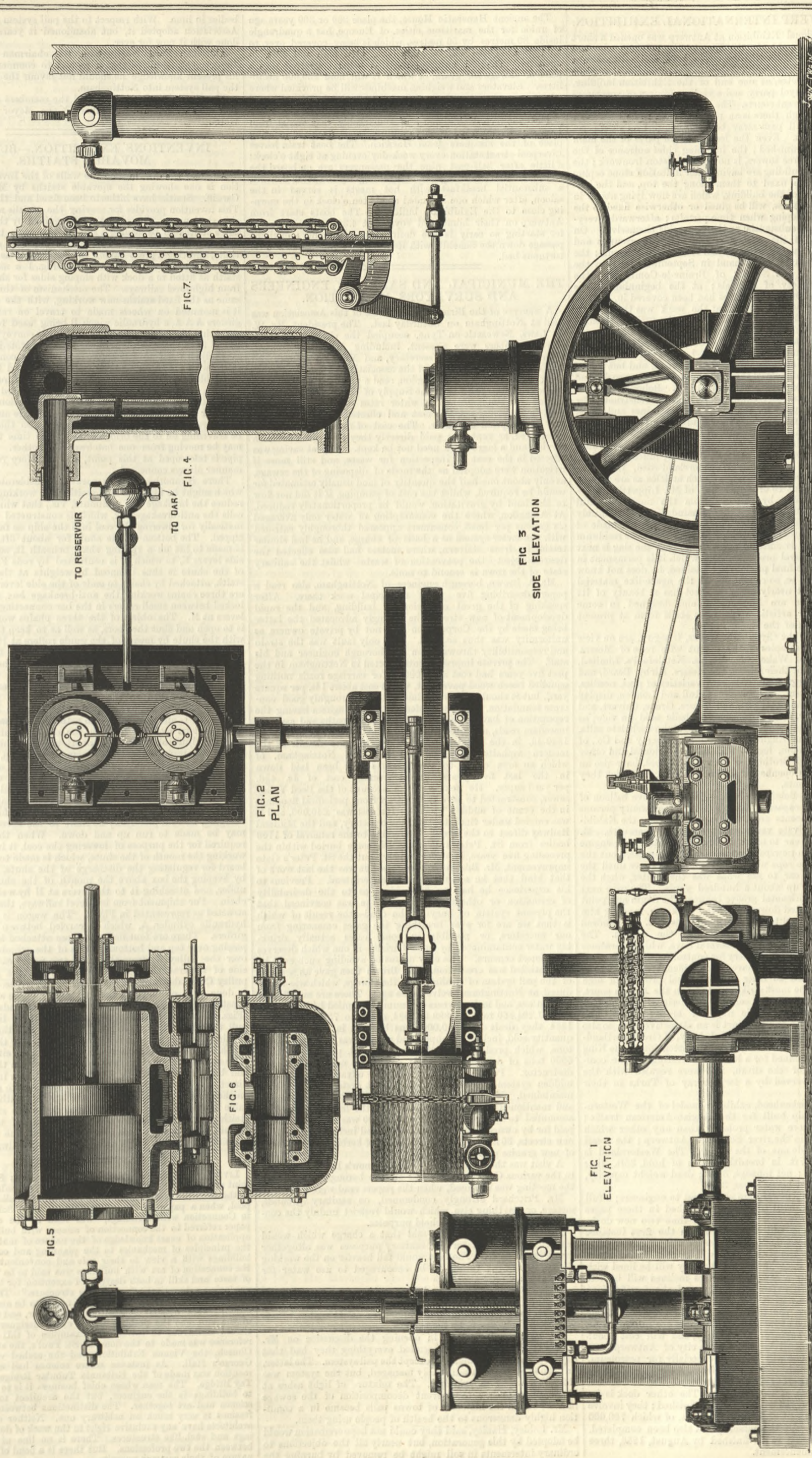
FIG. 2



THE INVENTIONS EXHIBITION—COMBINED STEAM ENGINE AND AIR COMPRESSING MACHINE

THE GENERAL ENGINE AND BOILER COMPANY, LONDON ENGINEERS.

(For description see page 397.)



THE ANTWERP INTERNATIONAL EXHIBITION.

THE International Exhibition at Antwerp was opened a short time since by Leopold II., the King of the Belgians, who was accompanied on the occasion by the Queen, and by the Count and Countess of Flanders. The opening ceremonies took place in the Salle des Fêtes, at one end of the Exhibition building, after which the royal party and a vast concourse of spectators inspected the different courts. The Exhibition is in an unfinished state, and although there is at present much to be seen in it, about a month will pass away before it can put on an appearance of completion. Even the less essential parts of the main building are not finished; the imposing chief entrance of the future, with its three towers, is now but skeleton ironwork; the deal walls of the building are having their imitation stone coping nailed or otherwise fixed to them along the top, and the imitation stone walls of the building, which are now lying about in the grounds in sections, will be glued or otherwise fixed to the boards below the coping when time permits; afterwards everything will look as substantial as the pyramids themselves. On the 1st May, 1884, the work of laying out the grounds and making the necessary excavations and removals was begun; the main building was taken in hand in September, 1884, by the Society Cockerill, the Society of Braine-le-Comte, and the Metallurgical Society of Brussels; at the beginning of the present year, 75,000 square metres had been covered in, but the demand for space was so great that the work was then undertaken of covering 18,000 metres extra, which partially accounts for the present backward state of the Exhibition building.

The Exhibition altogether is a fine one, but England is feebly represented therein. The area taken by English engineers in the spacious machine gallery is exceeding small, and but few of the exhibits to be displayed therein have arrived; Lowcock's and Green's fuel economisers are among them. Belgium occupies most space, and its chief exhibits are engines constructed by the Cockerill Company for the ventilation of mines and ships, and a mill for grain, constructed by Luther and erected by a Louvain firm. The English court in the main building is half empty, and contains plenty of unpacked cases. One exhibit here, comprising four stalls, attracts, however, much attention; it is that of Mr. A. Lippett, Westmoreland-road, Walworth, London, and consists of a variety of such articles as are usually made of glass; about 15 or 20 per cent. of Mr. Lippett's articles are undistinguishable by the eye from the most beautiful specimens of polished agate; the remainder are perceptibly made of some novel material. These articles are all made of slag from Middlesbrough ironworks. He says that the residuum of iron in the slag is smelted out by him, that the slag is next passed through several processes, after which it is permanent in the air. Until the final product is obtained, he does not know what colour it will be, so cannot obtain the agate-like material with certainty, but nearly every product has a beauty of its own. The articles are inexpensive, and designed in some instances with fair artistic ability; his stalls form at present the chief attraction of the English court.

Iron tubes, from the Clyde Tube Works, Glasgow, are on view in this court, also samples of the patent wire rope of Messrs. Cradock and Co., of Wakefield. Messrs. Nettlefold's, Limited, exhibit specimens of their screws, and Messrs. Kirby, Beard, and Co., of London, large quantities and varieties of pins, needles, and hairpins. Messrs. Johnson Bros., Hull and London, display their lubricating and other oils, and Messrs. Grace, Calvert, and Co., of Manchester, have samples of carbolic acid on view, as well as a large number of specimens of sulpho-carbolate salts. A little outside the English court, Messrs. Liberty and Co., of Regent-street, London, have a fine show of oriental and other silks; Messrs. Arup Brothers, of New Bond-street, have also an elegant display of Copenhagen fine art pottery, for which they are the English agents.

M. Toulet, the Belgian aeronaut, has a captive balloon of 4500 cubic metres capacity, capable of carrying twenty persons in the car. The ascents are made in grounds near the Exhibition, it being a private venture not connected therewith. M. Toulet entered the car to make the first ascent alone; the engine then, said a Belgian newspaper, "made a hellish noise," but the drum on which the rope was wound would not move until the aeronaut left the car to see what was the matter, when the balloon at once ran up about a hundred yards. The rope next sprang out of its horizontal groove between the drum and point of ascent, and knocked down one of the workmen, injuring him so severely that he had to be taken to the hospital. A hundred soldiers were called in, who hauled down the balloon. The ascents were then suspended for several days, while alterations were being made in the machinery for controlling the balloon.

The French and Italians have a magnificent display in the large courts devoted to their use. Colossal bronzes of high artistic merit are the most striking articles in the French court, and both French and Italians compete in merit with each other in the production of artistic work of bronze, brass, and hammered iron. The Indian Court is an attractive one; so also is that of Turkey, erected by Mr. R. J. Levy, of Great Portland-street, London; its luxuries attracted the attention of the King and Queen, who remained for a long time resting on the comfortable cushions of the divan, and were regaled with the national fig paste, served by a large array of Turks in their national costume.

Laird Bros., of Birkenhead, exhibit a model of the Westernland, a passenger ship built for the Belgian-American traffic; this ship draws more water probably than any other which makes the passage up the river Scheldt to Antwerp; the vessel itself is now alongside one of the quays. The Westernland is 450ft. in length, 47ft. in breadth; depth of hold, 35ft. 2in.; gross tonnage, 5736; net tonnage, 3690; dead weight capacity, 5000 tons: indicated horse-power, 3750.

The new docks at Antwerp are of interest to engineers; a full description of them, with plans, was published in these pages some eighteen months ago. About that time two new docks were commenced, and will be connected in the first instance with one of the present docks, but later on will have a separate entrance direct from the river. They will have an area of about 60 acres; length of quays, 3200 metres; they will be lined with quay walls, except in a few places where inclines will be left with a view to future extensions if some of the fortifications near can be done away with. The northern citadel of Antwerp recently stood where the docks are now in progress. Their depth of water will be about 30ft. The works are carried on by M. Gustave Royers, engineer to the city, and will cost about 6,000,000f., which will all be paid by the city of Antwerp. Of the two new docks one will be used especially for petroleum, the great bulk of which comes here from America, to supply Belgium and a large part of Europe. An installation for Russian petroleum is in course of construction. The other dock is for large vessels. The works are already half finished; they involve excavation to the extent of 1,600,000 metres, of which 700,000 have been finished; half the masonry has also been completed. Everything is expected to be finished by August, 1886, three years from the commencement.

The ancient Hanseatic House, the place 200 or 300 years ago of union for the maritime cities of Europe, has a quadrangle inside 30 metres by 50 metres, which is being covered over to hold silos. There will be sixty bins, 46ft. high and 13ft. in diameter. The old building itself is being converted into a place of storage for grain, of which it will hold 230,000 hectolitres. Elevators and weighing machines will be provided where necessary, and the work is expected to be finished by the end of this year.

The Antwerp Exhibition is of remarkably easy access from London, because it is but three minutes' walk from the mooring place of the steamers from Harwich. The boat train leaves Liverpool-street station every week-day evening at eight o'clock; a little after half-past nine the passengers are on board the boat, and next morning, while steaming up the river Scheldt, a substantial breakfast with hot meats is served in the saloon, after which one is landed about ten o'clock in the morning close to the Exhibition building. The boats start from Antwerp on their homeward voyage at 4.30 p.m.; the reason for starting so early is the desirability of making a daylight passage down the Scheldt, with its numerous sandbanks and its tortuous bed.

THE MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS ASSOCIATION.

A MEETING of the Birmingham district of this Association was held at Nottingham on Saturday last. The president, Mr. W. G. Laws, Newcastle-on-Tyne, occupied the chair, and about thirty members were present, including Mr. E. Pritchard, Birmingham, the district secretary, and Mr. C. W. Jones and Mr. T. Cole, the secretaries of the association.

Mr. George Winship, Abingdon, read a paper on "Some of the Advantages and Results of the Supply of Water by Meter." He argued that the incidence of water rates was often unfair, and that meters equalised the cost and effected a great saving in the consumption of water. The cost of meters need not be considered, as rent was paid directly they were attached to a service, and a large stock need not be kept. A great saving was effected in the cost of inspection for waste, and still more if irrigation were adopted as the mode of disposing of the sewage, as only about one-half the quantity of land usually estimated for would be required, whilst the cost of pumping, if it did not flow to the land by gravitation, would be proportionately reduced. At Abingdon, where the consumption of water only averaged six gallons per head, consumers appeared thoroughly satisfied with the meter system as a basis of charge, and he had similar testimony from Malvern, where meters had also effected the desired object—the prevention of waste—whilst the sanitary state of the town is second to none.

Mr. A. Brown, borough engineer of Nottingham, also read a paper, describing five years' municipal work there. After speaking of the great extension of building, and the rapid development of new streets, he strongly advocated the latter being made by the Corporation and not by private owners, as uniformity was thus secured. The only fault was the strain and responsibility thrown upon the borough engineer and his staff. The private improvements effected in Nottingham in the past five years had cost £210,000. For carriage roads nothing equalled beech wood pavement, which cost about 14s. per square yard, but it should always be laid upon a thoroughly good concrete foundation. He then referred to Nottingham having the reputation of having originated asphalte footpaths and asphalte macadam roads, and described some laid by Mr. Smart, about 1840-45, in the London-road. Then he gave details of the modern asphalte footpaths and roads in Nottingham, of which an area equal to twenty acres had been laid down in the last five years, at an average cost of 1s. 4½d. per yard super. He next gave an account of the Beed Valley sewer, constructed to save the district from periodical floodings in the event of sudden storms. Its cost was £40,000, and it was carried under Sneinton-hill, the cemetery, and the Midland Railway direct to the Trent. Referring to the removal of 1100 bodies from St. Peter's Churchyard, some buried within the preceding five years, in order to carry out the St. Peter's Gate improvement, Mr. Brown said he hoped it was the last work of that kind that he should have to superintend. Previous to his experience he had no fixed ideas as to the desirability of cremation or otherwise; but now he was convinced that the present system of burying the dead—the result of which is that we are for ever breathing the gases emanating from our ancestors, or possibly in some cases actually drinking water contaminated by such burials—is one which deserves the utmost censure. The only means of avoiding such evils he was satisfied was cremation. Mr. Brown then gave an account of the pail system of dealing with the sewage, which was introduced at Nottingham twelve years ago. There are now 31,155 pails in use, and in four years the number emptied had increased from 1,294,860 to 2,240,899 in 1884, equal to 73 per cent. In 1884 they dealt with 40,000 tons brought in pails, and the quantity sold, including ashpits and privies, was last year 75,000 tons, which produced £7145, about 1s. 6d. per ton. About 6000 tons of dry material were effectually consumed by the destructor. Pails were an undoubted advance on the old midden system, but that it was a perfect system could not be maintained. Mr. Brown then described the roads constructed, and mentioned that the expenditure of the last five years had amounted to £667,000, of which £210,000 was for new streets paid for by owners; and the work executed included 22 miles of new streets, 30 miles of sewers, 67 miles of kerbing, and 91 acres of new granite paving.

A visit was then paid to Sir John Oldknow's lace factory, and to the various Corporation works in the borough, after which the meeting was resumed, when the papers read were discussed.

Mr. Pritchard strongly condemned, on sanitary grounds, meters, or anything else which would restrict unduly the consumption of water for household purposes.

Mr. Gordon, Leicester, also said that a charge which would restrict the use of water for sanitary purposes was altogether wrong in principle. The cost would fall heavier on the working classes, who ought rather to be encouraged to use water for baths and sanitation.

Mr. Fowler, Manchester, and the president, expressed similar views, and Mr. Winship, Abingdon, in replying, admitted a check on the consumption was imperative at Abingdon, otherwise the supply would be inadequate.

Mr. Godfrey, Leicester, in opening the discussion on Mr. Brown's paper, highly commended everything they had that day inspected in Nottingham, except the pail system. The latter, he acknowledged, was admirably managed, but the system was altogether wrong in principle. The mixture of light ashes at Nottingham helped to prevent decomposition of the sewage matter, but in the majority of towns pails became in a condition highly dangerous to the health of people using them.

Mr. Lobley, Hanley, said they could not hope cremation would be adopted by this generation, but nearly all the objections to ordinary interments in soil might be removed by burning the bodies in lime. With respect to the pail system of sewage, that Association adopted it, but abandoned it years ago, and had done with it now for ever.

Alderman Ford, Nottingham, the chairman of the Health Department, admitted that if he had to commence again, with his present knowledge he should not favour the introduction of the pail system into Nottingham.

The discussion then closed, and the members of the Association were entertained at dinner by the Mayor at the George Hotel.

INVENTIONS EXHIBITION.—BUTLER'S MOVABLE STAITHS.

AMONGST the drawings on the walls of the Inventions Exhibition is one showing the movable staiths by Mr. S. Butler, of Cardiff. Staiths have hitherto been fixed and the ships moved. This invention provides for moving the staiths and keeping the ship stationary. The object to be gained by this is to enable three staiths to be loading a ship at the same time instead of one, which is calculated to increase the rate of loading five times, effecting a great saving in quay space as well as in the time of the ship. We illustrate at Fig. 1 a movable balance staith as fitted to a dock with sloping sides for shipment of coal from high-level railways. The mechanism of this staith is the same as the fixed staiths now working, with the exception that it is mounted on wheels made to travel on rails laid on the girders A A A, a hydraulic winch B being used for hauling the staith in either direction. The bridge for conveying the wagons to and from the staith is arranged on two pivots in order that it may adjust itself to any angle for retaining connection of the staith with the sidings. Over the pivots C and D are provided turntables, which may be better understood on reference to Fig. 2. The end of the bridge at C is mounted on a carriage provided for motion at right angles to the motion of the staith. In order to span the gap between the carriage and the sidings, sliding rails and foot-plates are provided, so that wagons may be travelling on to the bridge even at the time that the staith may be moving from one hatchway to another. The hydraulic pipe is telescoped at this point, and therefore remains in like manner always connected.

There is another new feature of considerable importance which might be fitted to any staith now working, which would reduce the breakage to a minimum, viz., that which Mr. Butler calls the anti-breakage box, which is constructed to work automatically for lowering the coal into the ship as fast as it can be tipped. The bottom of the shute for about 3ft. from its end is made to lift on a rocking shaft beneath it, actuated by the side levers E, to which it is connected by rods F. The mouth of the shute is thus balanced by weights at the back of the staith, attached by chains to ends of the side levers at G. There are three chains working the anti-breakage box, which may be locked between small rollers in the bar connecting the two side levers at H. The object of the three chains working the box is to open and shut the doors, as well as to keep the box square with the shute by means of the guide rollers at H. The centre chain of these three is attached to the cross-bar I, which in its turn is connected by chains to the doors. The two outside chains are connected to the cross-bar J, which in its turn is connected to the box. The box is lifted and lowered by the chain attached to the doors, worked by the hydraulic cylinder K. The chains attached to the box are kept tight by the weight L, and only come into action for discharging the box, which is done by large links in the chains coming in contact with an adjustable stop. The depth at which the box is to discharge is determined by the position of this stop, which can be put on a rack at any point along the floor of the staith. The action of the box therefore is to open the mouth of the shute on coming up to be filled, and to close it immediately it begins to descend. The box may be made to hold one to two tons, and being automatic in filling and discharging, there is practically no limit to the speed at which it may be made to run up and down. When the box is not required for the purpose of lowering the coal, it is still used for working the mouth of the shute, which is made to act as a wing board for regulating the discharge of the shute. This is done by keeping the box above the mouth of the shute instead of under, and attaching it to the levers at H by a short length of chain. For shipment from low-level railways, the staith is constructed as represented in Fig. 3. The wagon is lifted by the hydraulic cylinder A, which is carried between two upright girders. There are four flat wire ropes attached to the cylinder passing over top and bottom pulleys of the cylinder, and thence over the pulley B; from this point two ropes lead down to one side of the cradle, and the remaining two ropes pass over the pulley C and down to the other side of the cradle. The tipping is done by a chain from the cylinder D. The staiths may be constructed to discharge wagons from their ends or bottoms. (Figs. 4 and 5.) In this case the action of the lift is used to pull the staith to its position. The only additional appliance required for this purpose is a chain passing over the top of the staith, to which the cradle may be attached on either side. If it be attached to one side, the staith is drawn in that direction; and being attached to the other side it is drawn in the opposite direction. Each end of this chain is fastened to mooring posts on the quay at opposite ends of the staith's path. A traverse table is used for moving the wagons from the sidings to the staith; or in cases where the arrangement of the quay will permit, the swing bridge is used for retaining the connection of the sidings with the staith as with high-level railways.

LIVERPOOL ARCHITECTURAL AND ENGINEERING SOCIETIES.—A joint meeting of these Societies was held on Wednesday, May 13th, at the rooms of the Architectural Society, 9, Cook-street, Liverpool, when a paper by Mr. W. Goldstraw, on "Science and Art in Connection with Buildings," was read by the author. The paper referred to the connection of science with building as "the application of exact knowledge of the nature of materials, and of the principles of mechanics to the planning and construction of buildings with a view to their safe and convenient use;" whilst the connection of art with buildings was said to be "the exercise of taste and skill in both design and execution for the purpose of producing a beautiful effect in the structure." Thus regarded, science and art, or utility and beauty, ought to be amalgamated in building work without neutralising each other, and the balancing of the two was the problem which every designer of buildings should endeavour to solve. For examples of this happy union, reference was made to the dome of St. Paul's, the steeple of Bow Church, the Vienna Exhibition, and the arched vault over St. George's Hall. As instance where science had excluded art, mention was made of the Britannia Tubular Bridge and the new Tay Bridge. The man whose chief business it is to apply science to buildings is the engineer, but the architect must cultivate science and art together. The distinctions between the two professions is very much an arbitrary one. Neither engineers nor architects have any exclusive right to the work of designing buildings and such-like structures. There is no line of demarcation between the two professions. But there is a bond of union in the nature of their common pursuits.

PUBLISHER'S NOTICE.

**** With this week's number is issued as a Supplement, a Two-Page Engraving of Austrian Railway Diagrams for Estimating the Quantities of Girder Bridges. Every copy as issued by the Publisher contains this Supplement, and subscribers are requested to notify the fact should they not receive it.*

TO CORRESPONDENTS.

C. F. R.—*If you will send particulars of your invention, in confidence, we shall be in a position to advise.*

B. G. M.—*We never attempt to supply purchasers for patents, and cannot give you any information whatever on the subject.*

SUBSCRIBER.—"*Practical Geometry, Perspective and Engineering Drawing,*" *by Geo. S. Clarke, R.E. London: E. and F. N. Spon.*

T. P. (Middlesbrough).—*The Secretary of the Iron and Steel Institute, Victoria Mansions, Victoria-street, Westminster, may be able to supply the information you require. We have no list of the kind.*

R.—(1) *An ejector condenser, such as Morton's, will probably answer your purpose.* (2) *You can use a pitch chain as you propose.* (3) *No.* (4) *A constant lead.* (5) *Consult any small work "On Strains," such as Humber's, or see treatise "On Cranes" in Weale's Series.* (6) *About 2 to 1.*

PROFESSOR HANNAY'S ELECTROGINS.

(*To the Editor of The Engineer.*)

SIR,—Will any reader kindly favour us with the name and address of the manufacturer of Professor Hannay's "electrogins," used for boiler purposes?

W. N. J.

MEETINGS NEXT WEEK.

UNIVERSITY COLLEGE ENGINEERING SOCIETY.—Last ordinary meeting of session 1884-85, Friday, May 29th, at 8 p.m., when a paper will be read by Mr. R. F. Hayward "On Boiler Explosions." Professor Alex. B. W. Kennedy, M. Inst. C.E., in the chair.

SOCIETY OF TELEGRAPH ENGINEERS AND ELECTRICIANS.—Thursday, May 28th: "Ship Lighting by Glow Lamps, embodying Results of Trial for Economy in H.M.S. Colossus," by Mr. B. J. Farquharson, Member. "Electric Lighting at the Forth Bridge Works," by Mr. J. N. Schoolbred, B.A., M. Inst. C.E., Member.

DEATH.

On the 13th inst., at his residence, 41, Gloucester-gardens, Hyde Park, W., Mr. WILLIAM GEORGE OWEN, late Chief Engineer of the Great Western Railway, aged 74.

THE ENGINEER.

MAY 22, 1885.

THE LONDON SEWAGE INQUIRY.

A BLUE-BOOK has just been issued, containing the remainder of the evidence taken before the Royal Commission on Metropolitan Sewage Discharge. The former volume started from July, 1882, and the present one terminates in last October, finishing off with the answer to Question 19,689. The list of witnesses includes a long array of well-known names, and we find Sir Robert Rawlinson giving some interesting evidence as to the position and prospects of the sewage problem. He recognises the difficulties which lie in the way of sewage irrigation, and considers that the climate of England affords too little sunshine for success in the application of sewage to land. When it happens that the season is favourable to sewage farming, there is plenty of produce in the market, and prices rule low. Sewage irrigation is "very costly," and accordingly unprofitable. The Worthing sewage farm was well managed, it created no nuisance, and it yielded splendid crops; but it did not pay, and the sewage now goes into the sea. The most curious fact of all is, that there is a popular prejudice against sewage-grown produce. Sir R. Rawlinson states that this sentimental objection greatly retards the sale of milk and vegetables from a sewage farm. Sir Robert is convinced that this prejudice has no proper foundation; but, nevertheless, it exists. When Mr. Blackburn had the sewage farm at Aldershot, he told him that he had "the greatest difficulty" in getting rid of his produce, although it was acknowledged to be the best in the district. At Nottingham, more than 600 acres of land have lately been put under sewage; the soil is of suitable quality, and the area is admirably laid out. There are some very fine cattle sheds, and about 150 milch cows. There is no difficulty in selling the milk, one contractor taking the whole of it. But it goes to London, where nobody is any the wiser, and the sentimental objection does not present itself. There is also a quantity of young stock on the farm, and the managers get the highest price of any farmer in the district for their pigs, or their cattle, or whatever they grow there. So far, the sun seems to shine upon Nottingham, and it may inspire regret that so much sewage is now being thrown away which might help to produce milk for the London market, besides furnishing pigs and cattle, and other food supplies. The sewage of London would fertilise an enormous area; but, then, it would never pay. Neither would any other process pay. It is a matter almost of reproach that we are under the necessity of wasting so much valuable manure. Sir R. Rawlinson laid before the Royal Commissioners a report by Mr. Robert Ethridge, showing that 100 tons of London sewage possess a value of 17s. 7d. Of this amount, 15s. 4½d. is in the dissolved matter, leaving only 2s. 2½d. for that which is in suspension. On such a basis it is calculated that the total annual value of the fertilising materials in the whole of the metropolitan sewage is upwards of a million sterling. Yet Sir R. Rawlinson advised the Commissioners that the best mode of dealing with the London sewage was to convey it down to the mouth of the Thames, and there throw it into the estuary. He would have ten outlets, formed of cast iron pipes, not less than a quarter of a mile apart, on each side of the estuary, making twenty in all, the discharge to be continuous at all states of the tide. When this is accomplished, Sir Robert says, "I think you will have done for London all that you can be called upon to do; and I myself see no other way out of it." As our readers are aware, there are others who think differently from Sir R. Rawlinson on this point, and the Metropolitan Board are evidently resolved to try whether they cannot treat the sewage successfully at the present outfalls.

There is a striking map attached to the evidence, showing the chemical works and factories in the vicinity of the main drainage outfalls. Of these there are more than thirty. This map appertains to the evidence of Mr. G. Chatterton, who believes that the outfalls are made to bear more blame than belong to them in respect to malodorous effluvia. Between Greenwich and Woolwich, especially on the northern shore, there is a wonderful aggregation of noxious trades, and there is a considerable cluster on either side below Crossness. These establishments are all very useful, and it is a pity they cannot be made less disagreeable to the locality in which they are placed. If ever the outfall question is set at rest, the fish manure works, the glue works, and other unsavoury establishments will no longer be able to hide their own sins by a reference to the main drainage outfalls.

AN EPISODE IN AMERICAN CONTRACTING.

WE have more than once treated of the relations existing in this country between engineers and contractors, relations which are now and then, to say the least, unpleasant. We have shown that these usually find their origin in the incautious way in which specifications are signed by the contractor before he has mastered their contents. This want of caution is not confined to Great Britain, and even the quick-witted American, with all his native shrewdness, now and then finds out to his cost that the signing of documents whose contents he has not fully mastered may lead to sorrow. A remarkable instance of this is supplied by a little pamphlet circulated by Mr. A. Hartupee, an American engineer of eminence. The pamphlet is entitled, "A Brief History of the Building of the Engines of the Pittsburgh Waterworks, and How the City Paid for Them." In bringing the statements made by Mr. Hartupee before our readers, we wish it to be clearly understood that we in no sense or way vouch for their accuracy. On the other hand, we have no reason to doubt that they are true, substantially at all events. But on one point there can be no doubt—namely, that Mr. Hartupee and the municipal authorities of Pittsburgh have been in litigation for a number of years, and this fact alone would be sufficient to enable our readers to draw a useful lesson from Mr. Hartupee's statements.

In order that the growing city of Pittsburgh might be supplied with water, it was determined in 1872 that some very powerful pumping machinery should be put down. The machinery consisted mainly of two pairs of compound beam rotative engines. To give some idea of their gigantic dimensions it will suffice to say that the fly-wheels each weighed 100 tons, and that the low-pressure cylinder of one pair was 106in. diameter, with a piston stroke of 14ft. In 1872 Mr. Hartupee had the contract for the first pair of engines, to be completed on or before November 15th, 1873; for these he was to receive £84,700. In 1873 he entered into a second contract to supply the second pair, the contract price being £75,000. The foundations for both sets of engines were to be supplied by the municipal authorities. Mr. Lowry was the engineer, and the engines were constructed in many respects on his patent. The terms of the contract were such that all disputes arising between the contractor and the engineer during the progress of the work were to be settled by the engineer. It will be seen that this clause is identical with that usually inserted in specifications at this side of the water, to the effect that the engineer's decision shall be final. Mr. Hartupee signed his contract specifications with a light heart, and no disputes arose until 1875. The engineer objected to some parts of the engines, and they were at once rejected by Mr. Hartupee, and replaced by others with which he expressed his satisfaction. In the spring of 1875 the old trouble about extras arose. Mr. Lowry wanted alterations and additions to the value of £20,000 made. Mr. Hartupee obeyed instructions, but received no official order. After a large portion of the work had been done, Mr. Hartupee pressed for the official order, but could not get it. Then Mr. Hartupee refused to proceed further with the extras; and to protect himself for what he had already done, he appealed to the Water Committee, who at last gave orders for a large part of the extra work. Mr. Lowry stated as his excuse that he had not brought the matter up before, because "he was afraid the tax-payers would make such a howl about the expense." Mr. Hartupee asserts that from this period Mr. Lowry became antagonistic to him, and put all sorts of difficulties in his way. He first condemned five valve chambers, because they had what Mr. Hartupee calls "shrinkage cracks" in them. Some of the best founders in Pittsburg, called in as experts, pronounced the cracks of no moment, and Mr. Lowry satisfied himself that by "putting a plate under them" they would be strong enough; but after the plates were made he rejected the valve chambers, and new ones were cast, at an expense of £4000. He then directed that the valve chambers should be bedded on lead, of which nearly twenty tons were used. Mr. Hartupee protested, saying that the lead would squeeze out and leave the holding-down nuts slack; and this actually happened. The city then had two new and stronger chambers made by the Atlas Works, and one of these gave way shortly afterwards. The lead was taken out, and they were bedded iron to iron. Notwithstanding all delays, the engines were ready to start in April, 1878; but the boilers, with which Mr. Hartupee had nothing to do, were not ready, and a start was not made until July, 1878. After they were fairly in motion, the bottom fell out of one of the plungers, and, as the beam came back, the plunger caught in the dead weights, and there was, as may be imagined, a tremendous shock, but nothing was broken but a plummer block. We must now quote *verbatim* from Mr. Hartupee's statement:—"This accident was in no way caused by my fault. After the plungers were in place the city officers permitted the water to get into the pits, and thus they stood two winters; they were doubtless broken by the water freezing in them. As they never had been in use, no other cause for their breaking could be assigned. The damage thus caused was repaired by me. In the meantime the engineers commenced to bore through different parts of the machinery and take out pieces for testing. I objected to this for two or three reasons. First, because the contracts provided for casting pieces on each casting for the purpose of testing, and this had been done and the test pieces delivered to the engineer. I had a right to have the iron tested in this way, as provided by the contract. The mode adopted by the engineer was unfair, as the centre of cast iron is more porous than the outside, and by his mode this iron would be tested at the weakest point instead of at the average. This would make a difference of from 25 to 40 per cent., as was testified to by a dozen or more of the best founders and engineers of the city. The beams were the only parts which he tested according to the contract, and these showed the required strength. I believe that all the other important castings would have shown equally well if they had been tested in the same way. It was also unfair to me not to test them when the castings were first made, so that I would avoid the expense of finishing and putting them in place, which was as great as the cost of casting. In December of 1878 I again had the engines ready to start, and they were then entirely completed except the painting and some polishing. When ready to start, I notified the engineer that it was unsafe to do so without an air pump to supply air to the air chambers. No provision was made in the contracts for air pumps. He said if it was needed I must provide it, but gave me no order for it. I declined to furnish it without an order, and this was the excuse for forfeiting my contracts and taking the completed engines. I started the engines without air, and pumped water to Hiland-avenue. This was done on several occasions, but for want of air the vibration of the gauge was so great as to show it was dangerous to run them, and I told him—the engineer—I would not be responsible for them breaking if run without air pumps. On the 7th of February, 1879, the engineer, backed by the Mayor and police of the city, took possession of the engines, and in fifteen minutes put them in operation, and since that day to this they have with little interruption supplied the city with water. They were at different times disabled, as I claim and could prove, had I been allowed to do so, not from any defects in my work, but by reason of defects in plans and mismanagement and inefficiency in operation, and for want of proper supply of air. The people were for years annoyed with reports of the broken engines."

Mr. Hartupee goes on to describe several breakdowns which subsequently took place, for none of which does he hold himself responsible, and there can be no doubt that he makes out a very good case for himself. Of the thousands of pieces in these gigantic engines, only six supplied by Mr. Hartupee have broken, while ten times as many supplied by other engineers, after the city authorities had taken the engines, have failed. As to the cause of the failures, Mr. Hartupee says:—"It will occur to any mechanic who takes note of the parts of machinery broken, that they are all connected together—the valve chambers, the air chambers, and the wrists—and he would at once look for some local cause. The valve chambers were doubtless affected by the rocking caused by the lead foundation. No other cause could account for the breaking of the bolts connecting them with the check valve chambers. The breaking of the cushions and wrist is accounted for by the fact that the admission valves were too small to properly fill the pump barrels, and the consequence was that the plunger moved through a partial vacuum with 100-ton fly-wheel attached to it, and struck the water at rest, causing a shock which cannot be estimated. These two causes account for the breaking of the valve chambers and wrists. Both difficulties have been remedied in engines Nos. 1 and 2." "Wrists" are, we may add, crank pins.

Mr. Hartupee applied for his remedy, and, not to unduly prolong this article, it may be enough to state that he got a decision in his favour by the Hon. Judge White, who said "the city has committed a great wrong in annulling their contract, and they must not take advantage of that wrong by committing a double wrong, and it would be monstrous to say that the plaintiff had no standing in court." However, he was nonsuited on a technical point, and the case was carried to the Supreme Court. Now comes the point to which we wish to call special attention. Mr. Lowry was made arbitrator under the terms of the specification which constituted him sole authority in case of dispute, and the Supreme Court upheld his decision. At the time Mr. Hartupee had been paid £118,600, leaving due to him £61,000. By Mr. Lowry's award, not only did the contractor forfeit this sum, but he was condemned to pay the city £28,500 on the first contract, and £35,000 on the second for putting in bad iron. Thus on a contract amounting to £179,700, damages are awarded to the extent of £124,578, leaving the cost to the city of the engines £55,122 only. Mr. Hartupee says that he is ruined, which is, we think, very probable.

We have in the whole case a most instructive lesson. Mr. Hartupee has really no one to blame but himsel . "The contracts," he says, "with the city provided that in case any dispute arose between the city and me touching the quantity, quality, or value of the work, it should be submitted to the mechanical engineer. I supposed this was the ordinary agreement inserted in contracts for large work to prevent the stoppage of work if any differences arose during its progress. The Court held that under the contracts Lowry was the judge of all matters of law and fact, and his decision was final, and they therefore held that neither I nor my bondsman could question his decision, even if it was the result of mistakes or fraud. We offered to show gross mistakes and palpable fraud, and could have clearly shown it, but were not permitted to do so." The whole point turns on Mr. Hartupee "supposing." If he had taken the trouble to ascertain, before he signed the contract, for what he let himself in, he would probably be a wiser man to-day. The story is, however, not one that redounds to the credit of Mr. Lowry or the city authorities. Of course there is another side to it. There are always two sides to every story; but nothing can modify the fact that this great contract has been brought to a most unsatisfactory conclusion; and it may be added that the low-pressure cylinder has been found so uneconomical that it has been put out of use, and the engine is worked non-compound. It seems that American engineers have yet something to learn in the design and construction of large pumping engines for town water supply.

VOLUNTEER TORPEDO CORPS.

CERTAIN remarks made recently by the Duke of Cambridge during a discussion in the House of Lords on the question respecting the armament of our Artillery Volunteers, appears to us to have an essential bearing upon colonial defence. The Duke, on the occasion referred to, argued that light Horse Artillery is a branch of military service for which Volunteers are not fully fitted. In support of his contention he advanced two points: one being the exceptional character of the services demanded of the drivers of "galloper" guns, the other being the highly complicated character of the weapons which come under that denomination. A driver in the Horse Artillery Corps, his Royal Highness contended, cannot be trained to his work within a less period than from eight to nine months, passed with a daily exercise of several hours. The guns themselves, if they are to be trustworthy in active service, must be served by men whose training has been equally long and arduous, and who have been rendered capable by daily maintained exercise with them, of handling their complicated mechanism under circumstances most conducive to nervousness and haste. The conditions requisite, therefore, to make a good Horse Artilleryman were, he said, scarcely to be looked for among the members of our Volunteer Artillery Corps, the time that these are able to give to practice being but limited, and subject to constant interruption.

Now what the Duke of Cambridge so forcibly advanced with reference to Horse Artillery guns appears to us to have even a stronger bearing on the proposals which are being made in so many of our colonies to establish Volunteer Torpedo Corps. We believe that many men who are enthusiastic about so contributing their quota to the element of national defence are scarcely aware of the risks that would be involved in entrusting to them the handling of such complicated and valuable weapons as are our modern projectile torpedoes. If the risk the Duke of Cambridge pointed out as attaching to the handling of modern "galloper" guns, is great; far more so is that connected with the working of our torpedo system. The exhibits of these weapons in the Inventions Exhibition should fully prove to the most ardent Volunteer the complex and highly scientific character of the weapon he at present seeks to be entrusted with. The motive power—compressed air—of the Whitehead and other torpedoes is one demanding a knowledge for its use scarcely likely to be possessed by the great bulk of Volunteers. Then the engines can only be kept in working order by trained mechanics; while the charge of gun-cotton is extremely likely to deteriorate unless the utmost and constant care is given to its preservation. But, apart from this, the handling and direction of the weapon demands a training of a far higher standard than is necessary or is customarily given to other branches of the artillery service. If it be argued that the highest professional talent would be available for the officering of torpedo corps, it can only be answered that the very life of such corps must depend upon the efficiency of every member composing it, and the failure of even its lowest grade would bring about consequences of a gravity which would be scarcely likely to follow failure in any other branch.

Viewed alone from a pecuniary standpoint, we can hardly think it desirable to entrust what must, in insufficiently trained hands, prove a most erratic weapon to men whose opportunities for training in its use must be very limited. Practice by such with machines costing between £300 and £400 each might prove to be an experiment of considerable cost, and one which we should hardly think the authorities at the Admiralty would be willing to encourage. Even with our most highly trained torpedists the loss of these missiles is not altogether unknown, and their ultimate recovery at least uncertain. In the event of its being entrusted to incompetent hands, the torpedo may prove to be almost as erratic in its action as the war rocket has been found to be, and we very much doubt if it would be thought wise to entrust a rocket battery to the control of Volunteers. If it is intended to utilise Volunteer Torpedo Corps solely for the service of fixed torpedoes, of course our main objection would be considerably weakened; but even in that case such a service would not be without its danger, more, perhaps, to friend than to foe; and besides, any system of torpedo service which should exclude from it the use of the projectile torpedo must prove to be very incomplete—to lack, indeed, one of the main elements for harbour defence—and to be entirely wanting in that which would render it available for offensive operations. The colonies must, we suppose, be permitted to act in this matter as it seems to them best; but even within their limits we should presume competent men will be found who will point out the objections we have raised, and these will no doubt be strongly enforced by the Home authorities in the event of the formation of Volunteer Torpedo Corps being contemplated in this country.

The greatest fear expressed by military men as to the value of our Volunteer force in action is that, all being inexperienced men, its regiments would be lacking in that leaven of old soldiers which gives steadiness to the whole body of the rank and file of our regulars when first coming under fire. It is easy in such an experience to lose coolness and steadiness, prime qualities needed in dealing with the motive torpedo. Praiseworthy as is the Volunteer movement, and valuable as its services are sure to be in the event of necessity for home defence, we feel equally certain that its employment in two arms of the service, as Horse Artillery or as Torpedists, would be wanting in the elements which would make it not only effective against an enemy but safe to itself. Accidents in practice would, we fear, be common both with the guns and torpedoes, and, if commenced, it would soon be found desirable to discontinue it. The Duke of Cambridge was, it appears to us, quite right in the view he expressed that the training of Artillery Volunteers should be confined to guns of position, as also in his insistance that, valuable as they must prove as an adjunct to our regular forces, no efforts individuals might make could ever compensate for the want of that daily training and experience which can alone fit men to undertake the service of light horsed batteries or torpedoes as projectiles.

The movement in favour of the formation of a home Torpedo Corps rests on a somewhat different foundation, and it might, we believe, be possible to get together a picked body of men from the higher ranks of society, men possessing at once money, leisure, brains, and a certain amount of enthusiasm, who would form such a corps. We doubt, however, if the same conditions obtain in any of our colonies. It must not be forgotten that a Volunteer with a rifle in his hand is probably as useful a unit in the defending force of a country as it is possible for a non-professional soldier to be, and the circumstance that there are no doubt in the ranks of Volunteers of all denominations men capable of much better things than obeying orders with intelligence and good will, and of shooting straight, does not affect the question as a whole. We cannot, of course, say what the future development of the warlike spirit in our colonies may produce; but seeing that good Volunteer rifle corps can hardly yet be said to exist there, in the English sense of the word, we hold that it is at least premature to propose the formation of Torpedo Volunteer Corps.

STEEL AND IRON SHIPBUILDING.

THE marked rise in the price of steel plates, owing to the increase of the demand in a more rapid ratio than the increase in the production, will in some degree affect the immediate future of the question of iron and steel shipbuilding. Some years ago an able paper on "The Economical Advantages of Steel Shipbuilding" was read by Mr. William Denny. At that time Mr. Denny estimated the cost of the plate, angle, and bulb iron required for an iron vessel at the average price of £6 per ton. The price is now, we need scarcely point out, less than £5 per ton. At that date the production of steel plates was much less than it now is, and relatively steel plates were higher than they now are. But during the past few months the action has been in a different direction to what it was, that is to say, that whilst the price of iron plates has fallen the price of steel plates has risen, owing to the cause referred to above; and whilst at the beginning of the year the price of steel plates was not much more than £1 per ton above that of iron, it is now nearly £2 10s. per ton, and there does not seem very much likelihood of change in this respect just now; for not only have orders for merchant vessels of late gravitated to steel, but the increased activity in the building of vessels for the Navy will take up a large quantity of steel plates. At the same time, whilst there is practically no attempt to increase the production—or rather the facilities for the production—of iron plates, there are several extensions of the producing facilities for steel plates in progress, as well as the creation of new; and if we are unable in the immediate future to reckon upon the margin being reduced between the prices of steel and iron plates, yet it is certain that in a short time it must be, because the increase of the production will enlarge the competition and will enable the buyer to draw his supplies from a larger producing area. In the paper to which we have referred it was stated that "a considerable reduction in the price of steel plates" may be soon obtained. That was an expectation that is already fulfilled, for the price of steel plates is about £2 below that quoted four years ago. Mr. Denny expressed the opinion that steel would steadily lower in price "until it reaches an equality with the price of iron." As yet we have seen that this has not been the case, nor is it likely to come in the present year as far as can be foreseen, but in the future that expectation seems not unlikely to be fulfilled. For despite the increased demand for steel plates, there has been a lessening of the margin in the four years, and as the production is increased it may be readily expected that that margin will in time be minimised.

LITERATURE.

Die Graphische Behandlung der Mechanischen Wärmetheorie. By GUSTAV HERMANN. Berlin. 1885.

THIS is a reprint, and probably an extension, of a lecture on the "Graphic Treatment of the Mechanical Theory of Heat," given by Professor Hermann to the German Institution of Engineers at Mannheim, on 1st September of last year. He very justly points out that the modern theory of heat is not widely understood in any thorough practical fashion by engineers, and thinks that this results from its being always developed in text-books under an overwhelming and terrifying display of mathematical formulas. If experimental observations were more represented by accurately plotted curves on sectional paper, from the scales on which numerical results could be read off when desired, these experimental results would be more commonly made use of in practice. Otherwise each number wanted has to be calculated from some complicated empirical or theoretic algebraic formula, which probably after all gives the result with less accuracy than the curve does, because empiric formulæ are always only roughly approximative, and theories are still oftener incomplete, inasmuch as they leave out of account many small modifying influences. If, again, the numerical results of theoretic calculation were more often obtained by graphic construction drawn accurately to suitable scales, the avoidance of tedious analytical processes, in the depths of which is too often lost all consciousness of the real meaning of the whole operation, would encourage engineers to make practical use of the great results of modern scientific progress. As the consciousness of the meaning of the whole calculation from beginning to end becomes dimmer under the pressure of figures and algebraic symbols, so also does the risk of error in reaching the desired result become greater.

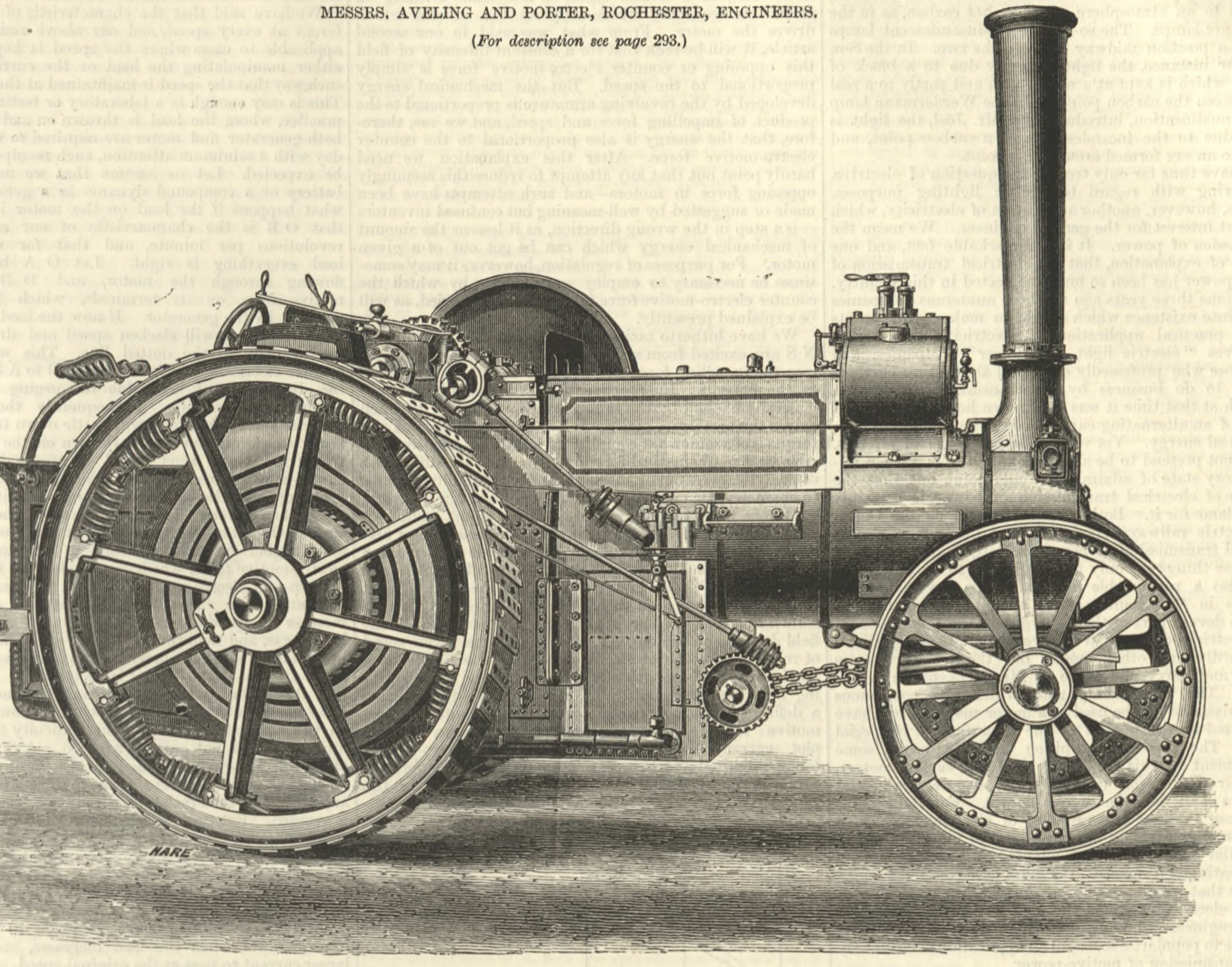
The present essay is a mere sketch, but it contains much that is suggestive, and applications are explained to many of the most important and difficult problems in practical steam engineering, such as the influence of steam jackets, the conduction of heat to and fro between the working steam and the cylinder walls, and the advisable grade of expansion. These problems are explained wholly by the help of diagrams, with practically not a single algebraic equation. Probably the example taken of the injurious effect of conduction of heat from the entering steam to the walls of an unjacketted cylinder is exaggerated. It is assumed that 25 per cent. of the whole heat given in the boiler to the steam may be conducted to the walls during the first half of the stroke. Now, there are experiments that show this amount of conduction, but they were almost certainly made on badly constructed engines, in whose cylinders water was allowed to accumulate. Professor Hermann shows that no advantage outweighing the extra quantity of steam used is to be obtained from steam jackets unless the jackets act so effectually as to keep the steam perfectly dry up to the last moment of its leaving the cylinder. It cannot, of course, be denied that there occurs a seriously large loss of efficiency in unjacketted cylinders owing to the conduction of heat away from the steam to the walls while the steam is hot, and its re-conduction back to the steam after it gets cold. The effect is a step in the direction of making the condenser temperature equal to that of the cylinder walls at their hottest, and of making the boiler temperature equal to that of these walls at their coolest. The steam efficiency is roughly proportional to the difference between boiler and condenser temperatures, and if we use a cylinder partially as a condenser and partially as a boiler—re-heater—there is no wonder that a loss of economy results. But it must not be supposed that there is no heat conducted from steam to cylinder walls that are jacketted. This does take place, and there is also condensation of steam during the first part of stroke in all steam engines—the action is only diminished, not wholly prevented, by jacketting. The action is very clearly explained by Professor Hermann's diagrams. Instead of using the usual co-ordinates of pressure and specific volume, Professor Hermann prefers to use temperature as the vertical ordinate and quantity of conducted heat divided by absolute temperature as horizontal ordinate. As the heat is not all conducted at one and the same temperature, the horizontal ordinate at any point of the diagram is really the sum of all the quotients of the various quantities of conducted heat each divided by the temperature at which it has been supplied by conduction. This sum is an important function well known to all students of the mechanical theory of heat. In English it has sometimes been called thermodynamic function, sometimes adiabatic function. In Germany they call it heat-weight, because it is shown that in heat engines it corresponds exactly to the weight of the driving substance in engines that drive by the force of gravity, while temperature corresponds to gravity level. This diagram of Hermann's is extremely instructive in explaining heat action in its various phases, but we can hardly recommend it as a convenient graphic method for practically calculating numerical results.

In all our text-books on Heat there is much reasoning about "reversible" operations, expansions, and the like; but nowhere is it explained what are the actual conditions of reversibility in any of these operations. Hermann takes trouble to explain that the sole necessary conditions of "reversibility" are two—namely, first, that the bodies between which heat-conduction is going on should be always at equal temperatures, and, second, that they should move together with equal *unaccelerated* velocities. Now this is exactly true; and it may no doubt considerably

THE INVENTIONS EXHIBITION—6-H.P. TRACTION ENGINE.

MESSRS. AVELING AND PORTER, ROCHESTER, ENGINEERS.

(*For description see page 293.*)



startle some of our readers who have not very carefully thought over the matter, to hear now for the first time that much, and perhaps the most important parts, of thermo-dynamical reasoning are based on the consideration of a process that is not only practically, but is also *theoretically*, impossible! Because no heat-conduction can, either practically or theoretically, take place between bodies at equal temperatures, even if we wait a million years for a single heat unit to pass; and therefore there are no possible reversible processes, either in practice or even in the purest theory. It seems curious that we should select such strictly imaginary and impossible conditions as a help towards arriving at scientific truth; but so it is. The misfortune is that, in proportion as we deviate in our engines from these even theoretically impossible conditions towards the practically and theoretically possible, so also do we reduce the economy of our machinery. The peculiar interest and value of Hermann's graphic diagram consists in that it brings this fact constantly into clear view. He gives a diagram in which all the losses are followed out graphically from the generation of the heat by combustion in the furnace down to that necessary loss involved in the fact that we cannot make our condensers cooler than the surrounding atmosphere without spending more power in doing so than we gain. In the special example worked out in this diagram, the loss by the gases going up the chimney hot is 19 per cent.; that consequent on our inability to use steam of such high pressure, that its temperature would equal that of the furnace, 40 per cent.; that involved in the gradual heating of the feed-water by conduction instead of raising its temperature by adiabatic compression, and thereafter conducting all the needful heat at the highest temperature only, 2 per cent.; that resulting from our not being able to carry the working expansion down to the condenser pressure, 5 per cent.; finally, that due to the condenser not being possibly lower in temperature than the outside temperature as 13 per cent. There is left 21 per cent. of useful work done. The calculation is only an approximate theoretic one for a high-pressure condensing engine, and losses by radiation from boiler and engine are neglected. The actual efficiency, of course, seldom reaches more than half this.

At the end of the book there are two very ingenious diagrams, one for air and one for water and steam, the titles of which may be translated rather lengthily as "Tables of Corresponding Thermal Conditions." They are pressure-volume diagrams, but they are also much more. The pressures and volumes are plotted off to logarithmic scales, so that the isothermals and adiabatics of air become all straight lines. By the help of the air diagram one may work out very many problems connected with air engines without reference to formulas and without arithmetic reckoning. Two objections may be urged, however, against this style of diagram. First, there are so many lines crossing each other at various angles that it is simply impossible to thread one's way through the maze without the help of a straight-edge. Secondly, the scale, being logarithmic, becomes a very close one at high values of the pressures, temperatures, &c. The steam and water diagram is available for any mixture of the two with not more than 30 per cent. of water in it. This diagram contains besides straight lines numerous curves, but the scales are more open in this case, and after a little study of the explanations given, we find it easy to obtain many useful results without having recourse to arithmetical calculation. An obstacle to the common use of this diagram is that the curves, which are numerous, are by no means very easy to construct.

THE WAVE THEORY OF LIGHT.

By PROF. OLIVER LODGE.

ON page 383 of your recent issue, under the head "A Scientific Mistake," is an article asking a question, an answer to which it is easy to give. The writer says he will be gratified by hearing that unsoundness in the wave theory of light has been admitted by teachers or writers of text-books.

To a certain extent I am able to gratify him, then; for, though I cannot answer for all teachers or text-books, I can assure him that the wave theory of light has been felt to be unsatisfactory ever since its inception at the beginning of this century. To call it "unsound" is too strong; to call it "unsatisfactory" is what all good teachers are, I believe, accustomed to do every time they expound it. Let me explain the difference.

A wave theory of light is certainly and demonstrably true. That is to say, light does consist of waves. But what does one mean by a wave? A hump on the top of the sea? That is one kind of wave, and by no means a very simple kind, but it is scarcely the kind that constitutes light. But what does one mean by a wave? An oscillation or vibration of some form of matter? Not necessarily. What then? A periodic disturbance? Yes, a disturbance of a medium *periodic both in space and time.* Note the definition.

Now light indubitably is periodic in space and time, and hence it is a wave motion. So far all is certain; and from this certainty alone a host of facts, diffraction, &c. &c., are instantly explicable. But now, when we try to go further and to ask what is moving? and with what sort of motion? we are landed in many difficulties; and progress is impeded, either by want of hypothesis altogether, or by cumbrous and artificial ones.

The natural early view was that the wave motion was a material motion just like motions to which we were accustomed in sound and other of the more tangible phenomena, although minute beyond ordinary recognition. This mechanical view of the wave theory, as an actual bodily oscillation of some jelly-like substance, seems to me doomed. With great ingenuity it can be made to account for a multitude of the facts, and it apparently numbers among its present adherents the magnificent name of Sir William Thomson. I venture to think, nevertheless, that it will be abandoned; and the periodic disturbance which constitutes light will be sought, not in the mechanical oscillation of ordinary matter, but in the subtle oscillation of the electric medium as conjectured and more than half verified by Clerk-Maxwell.

Calling a disturbance "electrical" instead of "mechanical" is rather like calling a phenomenon "chemical" instead of "physical," when we mean to say we do not understand it; but such a statement means more than simply saying we do not understand it—it relegates light to a host of more or less familiar phenomena with which every day we are becoming better acquainted; it marks its relationship and family in the general body of knowledge; and it gives us the assured hope that as soon as the nature of electricity is better and more intimately known, then will the nature of a wave of light also begin to be clearly and definitely intelligible.

University College, Liverpool, May 17th.

ELECTRICAL ENGINEERING AT THE INVENTIONS EXHIBITION.

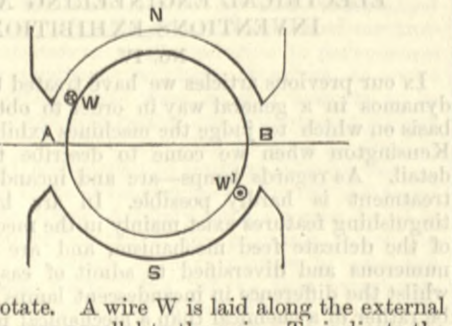
No. IV.

IN our previous articles we have treated the question of dynamos in a general way in order to obtain a scientific basis on which to judge the machines exhibited at South Kensington when we come to describe them more in detail. As regards lamps—arc and incandescent—such a treatment is hardly possible. In arc lamps the distinguishing features exist mainly in the mechanical details of the delicate feed mechanism, and are altogether too numerous and diversified to admit of easy classification, whilst the difference in incandescent lamps may be said to be rather of a chemical than a mechanical nature. It will be best to reserve details for our future description of certain lamps. A broad distinction can, however, be drawn between electric lamps with regard to the temperature at which the light is produced. In the arc lamps the temperature is highest, and the light is given out by white-hot particles of carbon floating in an atmosphere which fills the space between the two carbon points. The points themselves are also kept at a state of white heat, and especially the positive carbon—in direct current lamps—which forms a crater, contributes to the light. The carbon pencils are gradually consumed and must be approached in the same measure, so that the distance between the points, or the length of arc, as it is technically termed, shall be maintained as near as may be constant. In this case the carbons are placed in line opposite each other. In a modified arrangement the carbons are placed side by side, their distance apart determining the length of arc. The carbons may be either separated by air or by a layer of insulating material, which volatilises through the heat of the arc, and generally gives to the light a more or less objectionable colour, or rather variation of colour, brought about by impurities in the insulating material. These are the so-called electric candles. They require alternating currents in order that both carbons may be consumed at equal rate and the length of arc maintained constant. In the incandescent lamp the carbon filament is not consumed, or, to speak more correctly, it is consumed at a very slow rate, good lamps lasting from 1000 to 3000 hours. The light is simply due to the incandescence of the filament, but not to an atmosphere of white-hot carbon, as in the case of arc lamps. The so-called semi-incandescent lamps occupy a position midway between the two. In the Sun lamp, for instance, the light is partly due to a block of marble, which is kept at a white heat, and partly to a real arc between the carbon points. In the Werdermann lamp and its modification, introduced by Mr. Joel, the light is partly due to the incandescence of a carbon point, and partly to an arc formed around this point.

We have thus far only treated the question of electrica engineering with regard to electric lighting purposes. There is, however, another application of electricity, which has great interest for the general engineer. We mean the transmission of power. It is a remarkable fact, and one difficult of explanation, that the electrical transmission of motive power has been so much neglected in this country. When some three years ago all those numerous companies sprung into existence which sought to make great profits by the practical application of electricity, they styled themselves "electric light and power" companies, and even those who professedly employed alternating currents claimed to do business by the transmission of power, although at that time it was not known how the electrical energy of an alternating current could be converted into mechanical energy. Yet very little has come of all this. We do not pretend to be able to explain this rather unsatisfactory state of affairs, but would point out that the principle of electrical transmission of power is certainly not to blame for it. Both in America and on the Continent electric railways, tramways, and other examples of electrical transmission of power are largely in use, whilst here these things are only just beginning to be employed. It is also a remarkable fact that very few makers of dynamos in this country have thought it worth their while to devote part of their energies to the production of good electric motors. Up to a very short time ago there were hardly any other motors but those of Professors Ayrton and Perry and those of Mr. Reckenzaun in the market. The very facility with which any continuous current dynamo can be used as a motor may perhaps have contributed to the neglect of the manufacture of special motors. The present Exhibition shows, however, some improvement in this direction. We find several motors, and their application to numerous purposes, exhibited which we shall describe in due course. For the present we propose to treat the problem of electric motors in a general way and from a practical point of view, somewhat in a similar manner to that adopted in previous articles when treating of dynamos. We must take this opportunity to repeat that we do not address ourselves so much to professional electricians as to those of our readers who are general engineers, and amongst whom we would fain hope to be able to popularise so useful an application of electricity as the transmission of motive-power.

Into places which cannot be reached by shafting, belts, ropes, or steam pipes, it is always possible to carry a couple of small electric wires, whilst the power given out by an electric motor, in comparison to its weight and size, is very large. Thus, for instance, Mr. Reckenzaun is able to obtain 1-horse power for every 60 lb. weight of his motor, a performance which compares most favourably with any other kind of prime mover.

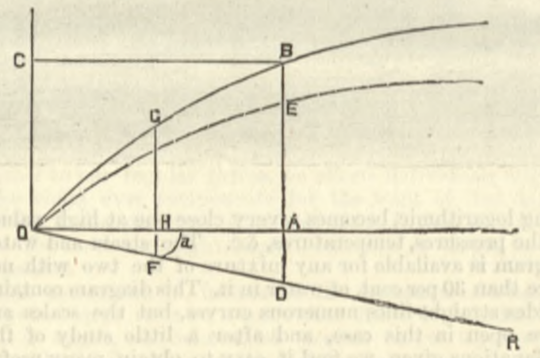
Turning now to our general problem, we must refer the reader back to our second article, page 339, where we explained how a wire traversed by a current experiences a resistance if moved across a field of magnetic lines of force so as to cut them. We then pointed out that the resistance is proportional to the product of current and strength of field. This force is, however, not of the nature of a dead resistance, as, for instance, friction, but it is a live force, impelling the wire transversely through the field. To fix ideas, let us assume we have a pair of poles, as per annexed sketch, between which an iron armature

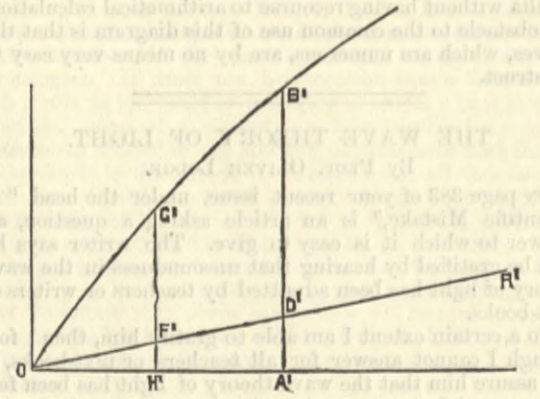


core is free to rotate. A wire W is laid along the external periphery of the core parallel to the axis. To indicate the direction of the current, we place a dot in the little circle representing the wire if the current flows from the observer, and a cross if it flows towards him. In the arrangement shown the wire W would be impelled to the right, and another wire W' would be impelled to the left, both combining to turn the armature in the direction of the hands of a watch. The movement continues until W arrives at B and W' at A. If in this instant the direction of the currents be reversed, the rotation will be continuous. This is the most simple form of an electric motor. In practice a number of such wires is employed, and the connections amongst them are similar to those on the armature of a dynamo, the reversal of current being performed by a commutator and brushes in the usual way. It will be seen that whilst the wire W advances to the right between the polar surface N and the external surface of the cylindrical core, it cuts through the lines of a strong magnetic field, and in consequence of this an electro-motive force is created in it quite distinct from that which sends the current through the wire. A moment's reflection will show that the direction of this electro-motive force must be opposed to the current, for were it otherwise, this force would strengthen the original current, and thus increase the power of the motor without a proportional increase in the primary source of power having previously taken place. This is clearly impossible, and contrary to the principle of conservation of energy. The motor when working acts therefore at the same time, in a certain sense, as a dynamo creating an electro-motive force which opposes the current which drives the motor. From what was said in our second article, it will be seen that for a constant intensity of field this opposing or counter electro-motive force is simply proportional to the speed. But the mechanical energy developed by the revolving armature is proportional to the product of impelling force and speed, and we see, therefore, that the energy is also proportional to the counter electro-motive force. After this explanation we need hardly point out that any attempt to reduce this seemingly opposing force in motors—and such attempts have been made or suggested by well-meaning but confused inventors —is a step in the wrong direction, as it lessens the amount of mechanical energy which can be got out of a given motor. For purposes of regulation, however, it may sometimes be necessary to employ some device by which the counter electro-motive force is automatically varied, as will be explained presently.

We have hitherto tacitly assumed that the field magnets N S are excited from some independent source, in which case the impelling force or torque is strictly proportional to the current. In practice, however, the magnets are generally excited by the same current, or part of it, which drives the motor, and the relation between current and torque is of a somewhat complicated nature not easily expressible by a mathematical formula. To avoid the difficulties of analytical treatment, electricians have generally recourse to characteristic curves similar to those used for dynamos.

Motors may be either series wound, shunt wound, or compound wound. We will consider the series motor first as being the type mostly used. The current is generated by a dynamo or by accumulators and sent along a line to the motor. It passes in series through the field magnet coils of the latter, then through its armature, and along a return line back to the generator. The strength of the field depends on the current, and since for a given speed of rotation the counter electro-motive force is directly proportional to the strength of field—neglecting the disturbing influence the armature has on the field—there exists a definite relation between current and counter electromotive force similar to that in a dynamo. If we plot currents horizontally and counter electro-motive forces produced at a constant speed vertically, we obtain a curve in general character somewhat like that in the annexed sketch. For low currents the counter electro-





motive force is proportional to the current, but for larger currents there is a falling-off in this proportionality due to the beginning of saturation of the field magnets. It must be borne in mind that the curve only represents this relation for one given speed; at all other speeds different curves would be obtained, the length of corresponding ordinates being simply in proportional to the speeds. To a current O A corresponds a counter electro-motive force A B; and since that is in proportion to the strength of field, the area of the rectangle O A B C is also proportional to the torque. Since the speed is constant, the energy developed is proportional to the torque; and we find, therefore, that the area of the rectangle O A B C can also be taken to represent the mechanical energy of the motor. This also follows from the consideration that the product of current O A, with counter electro-motive force A B, equals electrical energy transformed into mechanical energy. A certain amount of electro-motive force is required to drive the current through the motor, irrespective of that amount necessary to overcome the counter electromotive force. This is a loss, and is occasioned by the resistance of the exciting coils and armature wires. By Ohm's law this loss equals the product of resistance and current. If in our diagram we draw a straight line O R inclined at such an angle a to the axis of abscissæ that the tangent of this angle equals the resistance of the motor, the ordinates of this line give the electro-motive force lost through resistance. Thus, to produce a current O A we have to apply to the terminals of the motor an electro-motive force of A B + A D = D B volts. The electrical efficiency of the motor is represented by the ratio $\frac{AB}{DB}$, this being the proportion of external to counter electro-motive force. The commercial or total efficiency is somewhat lower, as a certain amount of power is lost through friction in journals, air resistance, and wasteful internal currents—magnetic friction—in the conversion of internal electrical to external mechanical energy.

We have said that the characteristic of a motor is different at every speed, and our above-remarks are only applicable to cases where the speed is kept constant by either manipulating the load or the current or both in such way that the speed is maintained at the desired value. This is easy enough in a laboratory or testing-room, but in practice, where the load is thrown on and off, and where both generator and motor are required to work day after day with a minimum attention, such manipulation cannot be expected. Let us assume that we use a secondary battery or a compound dynamo as a generator, and see what happens if the load on the motor is varied. Say that O B is the characteristic of our motor at 1000 revolutions per minute, and that for one particular load everything is right. Let O A be the current flowing through the motor, and D B the electromotive force on its terminals, which is maintained constant by the generator. If now the load on the motor be increased, it will slacken speed and drop its characteristic, say, to the dotted line. This will reduce the counter electro-motive force from A B to A E, thus leaving the difference B E available for urging more current through the machine. Consequently the torque will increase and the machine will settle down to its work at a lower speed. If now load is thrown off, the converse takes place; the motor runs faster, creates a higher counter electro-motive force, and thus checks the flow of current, using up less electrical energy, but running at a higher speed than before. In consequence of the reduction of current the intensity of the field of the motor is reduced, and a higher speed is necessary to produce the counter electro-motive force, which approaches the more nearly to the constant electro-motive force of the generator the less current is used. Thus we find that two causes tend to increase the speed of the motor; first, the reduction of the load *per se*, and then the weakening of its field consequent upon the reduction of current. In many cases this increase of speed is so large that it is necessary to keep a certain load always on in order to prevent the motor "running away." With a motor wound on the shunt principle, or on the compound principle, this difficulty is considerably diminished but not entirely avoided. A certain intensity of field is always maintained by the shunt coils whatever may be the main current passing through the motor at any time, and thus racing on account of weakness of field is avoided. But there still remains the difficulty that the speed slackens somewhat when the load is increased. Professors Ayrton and Perry have sought to overcome the difficulty by so compounding their motors that the main coils tend to demagnetise the field, thus weakening the latter when the current increases. In this way the counter electro-motive force is made to automatically become lower when the load increases, and to allow a larger current to pass at the original speed. It is questionable whether this principle can be recommended from a practical point of view, for with it at the very time when we want most torque we have the weakest field, and thus a larger motor must be employed than would otherwise be necessary.

The problem of a perfectly self-regulating motor is a difficult one if the condition be imposed that the motor should be worked from a generator which maintains a constant electro-motive force. But in the case that we are free to choose any dynamo we please for a generator, the problem presents no difficulty whatever. Referring again to our characteristic of a series wound motor, it will be evident that if by some means we are able to supply the motor with current at such an electro-motive force that in all cases the relation between O A and D B, as given by the curve, is maintained, the motor must work at the speed for which this characteristic curve is drawn. In other words, the electro-motive force of the generator should be the greater the heavier the load. This condition can be fulfilled by employing a series dynamo as generator. Let $O G_1 B_1$ be the characteristic of the generator and $O R_1$ its resistance inclusive of leads, then the electromotive force available at the terminals of the motor is represented by the ordinates contained between the curve and the line $O R_1$. Thus, to a current $O A_1$ corresponds an electro-motive force of $D_1 B_1$ volts, to a current $O H_1$ corresponds $F_1 G_1$ volts, and so on. If we can construct both motor and generator in such manner that the two curves coincide, that is to say, that $D B = D_1 B_1$, and $F G = F_1 G_1$, and so on for all currents, then we obtain a system absolutely self-regulating. If the generator dynamo is kept running at a constant speed the motor will also maintain a constant speed, no matter how much the load may vary between the extreme limits for which it is designed. The curves of similar dynamos resemble each other so much in general character that, as a rule, it is not even necessary to construct a special motor or generator when employing the system just described. Any slight deviation from the necessary coincidence between the curves can be corrected by inserting a small resistance into the circuit. The writer has applied this system, about eighteen months ago, in an installation for transmission of power to wood-working machinery, where the load was constantly varying. Two ordinary Bürgin series dynamos —the generator somewhat more powerful than the motor —were employed, and since the curves did not entirely coincide, a slight resistance was inserted into the circuit with the desired result.

Another method of preventing any excessive variation in speed, especially in the case of motors worked from accumulators, is that employed by Mr. Reckenzaun in his electric tramcar, a model of which is exhibited. We shall have more to say about this car on a future occasion, but for the present must content ourselves with a few words regarding the system of regulation. When connection is made between a series of accumulators and the motor at rest, the latter only offers electrical resistance to the current, but no counter electro-motive force. For an instant, until the motor has gathered speed, the current is therefore inconveniently large, and where the stopping and starting has to be performed at frequent intervals, as in the case of a tramcar, some provision must be made to lessen the strength of the starting current. This Mr. Reckenzaun does by employing two motors, which, by means of a switch, can be placed either parallel or in series. For starting the car the switch is placed to series, and the current from the accumulators must pass through one motor first, before it can reach the other. To further reduce any excess of current, some resistance is placed in connection with the starting lever, which, however, is cut out after the car is in motion. It will be seen that, when the motors are in series, each only gets half the electro-motive force of the cells, and thus the danger of racing when on a level road or on an incline is avoided. For heavy work the motors are placed parallel, and then about four times the energy is produced.

Space will only permit us to mention that some other electrical railways and tramways—notably that of Mr. Holroyd Smith—are exhibited, about which we shall have more to say in a future article.

LETTERS TO THE EDITOR.

[*We do not hold ourselves responsible for the opinions of our correspondents.*]

THE LAWS OF MOTION.

SIR,—The fun over the laws of motion seems to be getting fast and furious. May I use your columns to subscribe my adhesion to the proposal to use the word "inertia" for what Professor Lodge would prefer to express by the word "reaction," and what Clifford called "mass-acceleration?" This latter term is distinctly barbarous and ambiguous. According to English analogies it would properly mean "acceleration of mass," which is almost an absurdity. What it is meant to mean is "mass" multiplied by "accleration," but there are very various kinds of accleration, and the phrase includes nothing to hint that it is acceleration of velocity that is intended. To eliminate this ambiguity one would need to write "mass-velocity-acceleration;" but, considering no objection but the clumsiness of this phrase, we find that "acceleration of momentum" is precisely the same thing, is neater, is already commonly used and distinctly understood, and is also good English.

This last expression serves all the purposes required, but a shorter one seems to be generally desired, and I agree that it would be convenient to have it. I have for many years desired to use "inertia" in this sense, but have refrained because, although it is often used so, it is still oftener used in another sense. It is an entirely unnecessary word in that other more commonly used sense. Generally it is used in the vaguest possible fashion, but when it is used definitely it is usually made to mean precisely the same as "mass." Perhaps that may be denied, and it asserted that it rather means "mass multiplied by unit acceleration of velocity." Evidently the two are at least numerically the same, but further I do not think that means in mechanics anything else than momentum divided by velocity, or acceleration of momentum divided by acceleration of velocity. Mass is, as I said in a previous communication, merely capacity for motion. Thus "mass" being identical with, or, at any rate, strictly equivalent to the more common meaning of "inertia," clearly the word inertia is superfluous in this sense, there being another distinct and unambiguous term meaning exactly the same thing. Since "inertia" is also frequently used for "acceleration of momentum," that is, "time-rate of absorbing momentum," I wish to express my adherence to the proposal to appropriate definitely and once for all this word to this particular meaning alone, which it will express very shortly and intelligibly.

My objections to the word reaction to indicate the same idea are two-fold. In the first place, it is thoroughly ambiguous and must remain so, because it not only has been used in many different strictly defined senses at various times, but is also used at present by Thomson and Tait, who are certain to remain great authorities on mechanics for a long time to come, to express a quantity entirely different to that referred to by Prof. Lodge, even of altogether different dimensions. Secondly, the "re" in the word distinctly indicates a backward action. If it is to have Prof. Lodge's and not Thomson and Tait's dimensions, this backward action can only mean the backward force exerted by the accelerated mass upon the mass which is accelerating it. Now this is precisely what Professor Lodge does not wish it to mean; in fact he very properly insists that what he desires to express is no backward action at all, but simply an action of absorption of momentum. Therefore it seems clear that he has not chosen his word rightly. Nothing is more certain than that the prefix "re," both etymologically and even to those who know nothing about etymology, points at once to the backward direction of the action. I may add that the word "reaction" has an ancient and a fishy smell about it that does not please my personal taste, but that is a point on which others may well differ from me, and which is also of little importance of any kind.

Using "inertia" as proposed, we would have "centripetal inertia," the short for "centripetal acceleration of momentum." The circling mass must be guided in its circular path by some guiding body which forces it to deviate from the straight path—forces it in towards the centre. This inward guiding force, exerted by the guiding body upon the body guided in the curved path, is the centripetal force, which centripetal force, exerted by the guiding body is absorbed in the centripetal inertia of the guided body. Of course the guided body presses or pulls outwards against the guiding body; it reacts upon this latter with a centrifugal force equal and opposite to the centripetal force exerted on itself. If there is a number of centripetal and centrifugal forces exerted upon a body by external bodies, the centripetal inertia equals the excess of the centripetal over the centrifugal external forces, and the resultant centrifugal force which this body exerts externally—that is outwards upon other bodies—is equal and opposite to this excess.

I can think of no well-founded objection to appropriating the word "inertia" to this definite meaning.

We cannot conveniently do without the word "resistance." It is used by all engineers in a perfectly uniform and definite way—namely, to mean a force against which work is done. It is opposed to "driving effort." ROBERT H. SMITH.

The Mason Science College, Birmingham,
May 18th.

SIR,—I must declaim all responsibility for the words "to settle" which have somehow been inserted into the concluding paragraph of my last article, p. 380. In my view there is nothing "to settle;" everything has been practically "settled" since Newton's time. The trouble required is for the purpose of *understanding* clearly and fully what is settled.

I regret the letter of "A Girton Girl" in your previous issue, p. 350, because it only darkens counsel by words without wisdom. The mistake she makes is a very natural one, and one of which I myself am not altogether innocent—see correction of slip by me on p. 350, March 27th; but the repetition of it is not likely to do any good or to clarify the subject. That which "A Girton Girl" calls a "truism" is, I regret to say, not even true.

May 18th. OLIVER J. LODGE.

SIR,—The argument in both my former letters, showing that mass cannot be a consequent of an accelerating force, Prof. Oliver Lodge has not attempted to refute, but instead, strings together "such a man," "arrogance," and "ignorance," applied to myself. What on earth has that effusion to do with the laws of motion? He should produce the mathematical proof, which he has been asked for before, that his equation—

$$m\,d\,v = f\,d\,t$$

is perfectly true as an expression for a general law. Until this is done, no progress can be made.

The perusal of the candid and able arguments of other correspondents on this interesting subject has afforded me much pleasure. Some appear to favour the idea that the tractive force of the horse is not the effective cause of motion in the cart, any more than a spur in a river is the effective cause of motion in the water passing round its flank. Perhaps with increased knowledge of what constitutes force and inertia, it may be found to be correct, but at present it is pure conjecture, except so far that it appears to be a legitimate deduction from Newton's law reaction = action, the truth of which law I suppose no one will question.

Leominster, May 18th. W. H. LONGMORE.

SIR,—I have read everything that Dr. Lodge has written in THE ENGINEER concerning the laws of motion three times. It is not my fault, but my misfortune, if I have made any mistake concerning his views. The paragraph with which his last article concludes, beginning "The whole of dynamics is involved in this matter," is very nearly identical with a statement I made some years ago in your pages in the same connection. The great importance of the subject thus fully recognised by Dr. Lodge is my excuse for again asking you for space to continue this discussion. The fact that Dr. Lodge has accepted my definition of inertia would alone serve to more than repay me for any trouble I have taken in the matter. To have a satisfactory definition of even one thing connected with the laws of motion is a great stride.

Before proceeding to reply to Dr. Lodge's arguments, let me correct a misapprehension or two of his. First, then, I in no way hold him accountable for my "curious doctrine that force is not a cause of motion;" that is my own view. I do not despair of seeing it Dr. Lodge's view also in time to come. Secondly, I do not dream of "fathering Mr. Magnus's foggy statement" on Dr. Lodge. I quoted the passage to illustrate my contention that the text-books put into students' hands do not teach sound science. As Dr. Lodge has characterised the passage I quoted as "foggy," I need say nothing more on the subject. Thirdly, I never for one moment supposed that, to use Dr. Lodge's words, "a truck resists its own motion." It is to be observed that he does not father the statement on me directly; but the context of the passage almost makes me think that he does not yet fully comprehend what my views are. "This is what causes him," writes Dr. Lodge, "if he be at all logical, to knock himself against the old puzzle. If the truck resists its own motion with whatever force I push it, how can it move?" I never dreamt of such a thing. My contention is that it "may resist other trucks, or a man, or a horse, or an engine, but not itself." This Dr. Lodge admits. They are his own words within the quotation marks. What I contend is that it resists the other truck, or the man, or the horse, or the engine with quite as much effort as the horse, man, truck, or engine exerts on it; that, in short, a stress is set up; and I hold that this is asserted by Newton's third law.

The great danger of all discussions such as this is that they may drift into side ways, and become intolerably diffuse. To prevent this, as far as lies in my power, I will try to settle one issue at a time; and I think that I cannot do better than summarise the present position of the question.

I assert that there cannot be such a thing as an unbalanced force; so does Dr. Lodge. Thus far we are agreed.

I assert that a balanced force cannot be the cause of motion. Dr. Lodge grants this, but he asserts that an impelling force can only be balanced by something and motion. In other words, let the impelling force be A, then the opposite force is made up of B+C, which are together = A. In this compound C is accelerated motion.

Now, one difficulty which faces me here is that I do not quite know what B is. I take it for granted, however, that it is Newton's "pull" or the stress on a trace or rope; and in order that this stress may cause the motion of the body pulled, the pull on one end—the horse's end, that is to say—must, says Dr. Lodge, be greater than that on the other end. But this by the nature of things is impossible, and so says Dr. Lodge; but although the "pull" at the cart's end of the rope is partly pull, it is partly accelerated motion—that is to say, as I understand it, motion appears in a tangible form to our senses—as shown by a dynamometer hand, let us say—as pull. I freely confess that I am entirely unable to grasp the idea of the movement of a body being at one and the same time movement and pull. I will quote Dr. Lodge's own words:—"'Φ. Π.' is evidently labouring under the delusion that forces, being always balanced, are incompetent to produce or destroy motion, whereas the truth is that whenever a body is being either accelerated or retarded, although the whole force may be rightly regarded as balanced, yet it is only so balanced by reason of the particular amount of change of motion which is being caused. This constitutes one of the terms in the system of balanced forces." It will be seen that the phrase "whole force" is very vague. No doubt what he means is, the "whole force of pull or push is balanced." May I venture to ask Dr. Lodge to read this statement over very carefully, and having done so, to tell me, if he can, how I am to calculate how much of the whole effort or resistance is motion, and how much something else? and further, whether—friction and the resistance of the air, &c., being left out—the whole of the resistance is not motion? And if this is the case, resistance being force, is it not perfectly legitimate to say that motion is force? or, to put it into simple language, the movement of a body is a pull? It was precisely this line of reasoning, I believe, which led Tait to assert that force is the rate of acceleration of momentum; and with this view I do not think Dr. Lodge agrees.

I hope I have made my meaning clear. At some risk of being tiresome, I will try to be yet more explicit. I hold that a pull is one thing, and I hold that the motion of a body is quite another thing. No ordinary thinker will ever confound the pull on a trace or the tension of a rope with the motion of the cart pulled. To Dr. Lodge's mind the pull of the horse is the *cause* of the motion of the cart. He does not say that any part of *this* pull is motion. It is pull, pure and simple. But the pull of the cart is quite another affair. It is partly pull and partly motion; or all motion, the motion appearing not as motion but as pull so far as the trace is concerned, yet remaining motion so far as the cart is concerned. Why this distinction? If, as is possible, he says that this is not what he means, but that the motion of the cart is the cause of its pull, I must ask him what is the difference between this thesis and my own, viz., that motion is the cause of force—pull being here regarded as a force—and that whenever one body transfers some of its motion to another a stress is set up? The moment that Dr. Lodge concedes that the pull of the cart—motion or no motion—is identical with that of the horse, he has conceded one point in this controversy which I regard as of very great importance, and so far he and I will be in perfect accord; but should he maintain that the pull of the horse, regarded as a pull, is greater than the pull of the cart, regarded as a pull, there can be no agreement between us. Until I have a definite expression of Dr. Lodge's views on this point, I can go no further with this section of the subject, because I do not want to fight phantoms, and I may have quite failed to understand Dr. Lodge's meaning. To put the matter in a nutshell, I will therefore once more ask Dr. Lodge, Is the pull of a pulled body—a cart, for example—equal to the pull of the pulling body—a horse, let us say? After we have settled this point we may proceed to consider, if necessary, whether it is possible or not for motion not converted into pull to be the equivalent of a pull.

To proceed to another section of the subject. I understand Dr. Lodge to say that force is the sole cause of motion; that is, as far as concerns crude mundane things, such as carts, garden rollers, chairs, and the like. It is quite possible that he may have reservations regarding chemical action, light, and so on; but these we need not bring in at present. I have before now pointed out that, whatever may be contended concerning acceleration of motion, the initiation of motion presents hopeless difficulties to those who hold, at one and the same time, that all forces are balanced, and that force is a cause of motion. The difficulty has been, in a sense, attempted to be got over by asserting, as Professor Hudson did, that the ground pushes the horse more than it pushes the cart, and so on. Now, I am about to put a question to Dr. Lodge which eliminates the ground altogether, and leaves us as completely as possible dealing with force and matter only in their most elementary forms. Here is the problem.

According to Newton, a stone pushes up against the action of gravity just as much as gravity pushes down upon it. There is absolutely no escape from this. A stone is flung vertically into the air, and its motion gradually departs. It is transferred to something else, no matter now what. At last, for a fraction of time, the stone is absolutely at rest in mid air. Will Dr. Lodge tell me why it does not remain at rest? The force of gravity is impelling it earthwards, but the stone is by Newton's third law pressing upward against gravity with identically the same force. There is a condition of absolute equilibrium—a perfect balancing of two forces only. There is nothing of reaction in any complex form to be dealt with; there is no momentum, nor acceleration, nor retardation. The stone is absolutely at rest as regards the position of a spot of earth directly beneath it. There is no more reason why it should move than there is for one of the girders of Blackfriars railway bridge moving down through the abutment. That does not move, although gravity presses it down, because the abutment presses it up. In the same way, the stone in mid air presses up against gravity, just as, to use Dr. Lodge's own words, replying to your correspondent "An Old Student," "the ladder rung is exerting an upward force equal to the pressure of the man's foot." Yet the stone falls. Clearly we have a case here of two perfectly balanced forces, and yet we have motion. Furthermore, as the stone falls, it may be pointed out that every instant of time the upward thrust of the stone against gravity is as great as the downward push of gravity upon it. Here we have two efforts from the first and at every instant of time, balanced, yet accompanied by accelerated motion. Can Dr. Lodge, with these facts before him, assert that the *force*—effort—of gravity is the cause of the motion of the stone?

My explanation of the matter is, of course, simply that a stress is set up, as is invariably the case when motion is transferred from one body to another, and that gravity effort, being itself due to the motion of some subtle form of matter, part of this motion is transferred to the stone which descends, stress and stone moving along together, just as a stick may float down a stream. I run a great deal of risk in making this statement, lest a disquisition on the nature of gravity should be lugged—not by Dr. Lodge—neck and heels into this discussion; but I could not resist the temptation to give a hint at a solution of what must, I think, prove an insuperable difficulty to Dr. Lodge.

One word more concerning our old friend, the tug-of-war, rapidly becoming hoary in our service. Dr. Lodge has stated that the reason why one set of boys or men win and other do not is, that although the pull on the rope is the same at both ends, the thrusts on the ground are not. Will Dr. Lodge get a plank, put it on two or three good rollers on the floor of one of his class-rooms, and put one strong young man near one end and one weak young man near the other end, both standing on the plank. Let them pull on each end of a rope, and see what will happen? As there cannot be more thrust in this case for one boy than the other, they may, on Dr. Lodge's showing, pull for ever without the slightest advantage being gained by either side. Should this turn out not to be the case, perhaps Dr. Lodge will kindly explain how there can be more thrust at one end of the plank than the other, assuming that the plank, like the rope, has no mass. Φ. Π.

London, May 19th.

SIR,—In his very courteous and explicit answer to my letter published in your impression of May 8th, "Φ. Π." puts two questions to me, which I am sure he expects me to answer, otherwise I should not again have ventured to ask for space in your valuable columns, especially as in his article of May 15th Professor Lodge has so ably and lucidly expressed my meaning that not another word is necessary from me upon the subject. I wish to say that for some unaccountable reason I had not read "Φ. Π.'s" letter of April 3rd, and although I have read his former letters with great interest—I can recall one as far back as 1882, which gave me a good deal to think about—I do not think that any one of them has given me so clear a comprehension of his theory as this one of April 3rd, which I have carefully read many times. I believe I do now grasp his meaning, and he certainly does not appear to find himself in any difficulty, but, unfortunately, instead of helping me to agree with him, as I should really like to do, his letter only makes me feel the absolute impossibility of agreeing with him at all. For unless the disputants have some common ground of belief on which to found an argument, it really does not appear to me that any discussion is possible. And, indeed, in trying fairly to answer "Φ. Π.'s" questions, I constantly find myself employing terms the very use of which is forbidden by the nature of his hypothesis, and I am quite sure that when he reads my answers he will tell me I am arguing in a circle. I have often thought that however strongly one might differ from Berkeley in his belief that matter doesn't exist, no one who really understood him would ever try to persuade him that it *does*, for by its very nature his theory prohibits all possibility of disproof. And in the same way I am now quite convinced that were I to reason till doomsday, I should never persuade "Φ. Π." that there is anything in my views, because the very phenomena, the *very proofs* I should like to adduce in support of them he will tell me are not available, because they already *assume* the very theory I want to make them *prove*. "Φ. Π." asks me why I believe, as I evidently do, that Force is the cause of motion? I believe it I suppose partly because I have always been so taught, but much more I am sure because I have no experience of Motion without some antecedent Force to produce it. I know that if, with the intention of moving, I press against or pull towards me, any great weight—a heavily-laden trunk, for instance—I put forth what I believe to be Force. "Φ. Π." will see that I take my own action, as an example, because the only *positive* knowledge I can have of Force must be subjective, derived, that is, from my own sensations; all other knowledge must be inferential. Our only measure of the Force exerted by inanimate agents is the motion produced or work done, and, of course, to insist upon *Motion produced* as a proof of *Force exerted* in a discussion with "Φ. Π.," would be merely begging the question. Of course, I can't become the steam in a tea-kettle and say how it feels when it is pressing against the weight of the lid, nor can I tell what the sensations of the trunk may be when gravity pulls it in one direction and I drag it in another. I can only say that when *I* press with all my strength against a solid body, no matter whether it be a wall, or a door, or a heavy trunk, I feel very much as if I were putting forth Force, and if any living being chanced to be the object I came in contact with instead of the inanimate trunk, I rather think that person would think so too. My reasons for thinking that I am exerting Force are that I soon begin to feel hot, tired, then exhausted, perhaps hungry, and *certainly* unless that trunk soon begins to move, *cross*. But I think "Φ. Π." will admit that in pushing or pulling any solid body I *have* put out Force? Can he really then think me so very unreasonable in believing that as Motion invariably takes place after my Effort, and apparently in proportion to it, I should be inclined to regard the Effort and the Motion as Cause and Effect?

Then, as to question No. 2. "Φ. Π." asks why I believe that Motion can balance a Force? I thought I made it clear in my letter of the 8th that I believe Motion to be one *sign* of Force, one *manifestation* of Force. It is not the Motion *in itself*—that is, not the *mere change* from one part of space to another, which I believe helps to balance the horse's action, but the *Force*, the

Energy in the cart of which that motion is the indication. And when I said that the motion of the cart plus its weight equalled the horse's action, I meant to suggest that while one portion of the horse's action or Force is employed in balancing the resistance of the ground, the remainder is transmitted to the cart and manifested in motion; or, given a certain amount of Force put forth by the horse, then the greater the resistance of gravity, or the heavier the cart, the less would be the remaining Energy to be used in producing motion, and *vice versâ*. Again, if I throw a ball through the air, part of my expended Energy has surely gone in overcoming or neutralising the resistance offered by gravity, while the equivalent to the remainder of it is found in the capacity of the ball to do work. Will "Φ. Π." deny that it *can* do work? At any rate, it might put out a child's eye, or smash the roof of a glass-house, or knock a bird off a twig. Are these merely incidental occurrences, and not consequent upon the contact of the moving ball? I have tried to state clearly what I mean. My view may not be a very sensible one, but at any rate it appears to be the same as that held by Professor Lodge. Compare his words—page 380: "The total reaction of the cart, taking into account the acceleration being produced in it, as well as the resistance experienced by it, is exactly equal and opposite to the pull of the horse" —with mine—page 350: "In short, the motion of the cart × its weight form together a constant sum equalling the action of the horse."

And now, may I ask "Φ. Π." one question—not with any idea of confusing him, but in the hope that he will enlighten me? Can Force do work? I gather from his letters that he does not consider that it can, for he asserts that Force can never be a cause of motion, and as it is certainly *motion* of some kind which is usually the cause of work, it seems to follow that Force cannot be a cause of work; and if Force cannot do work, one cannot help asking what is the good of it, and why it exists. It seemed very useful as long as it was a cause of work, but regarded as a mere effect of motion, it really does seem to be a great fuss about nothing. A GIRTON GIRL.

May 20th.

SIR,—Let me thank Dr. Lodge for his replies to my queries. Inasmuch, however, as it seems that they admit each of two definite, precise, but conflicting replies, I am not sure that I am really much wiser than I was before. AN OLD STUDENT.

May 20th.

THE TILBURY DEEP WATER DOCK.

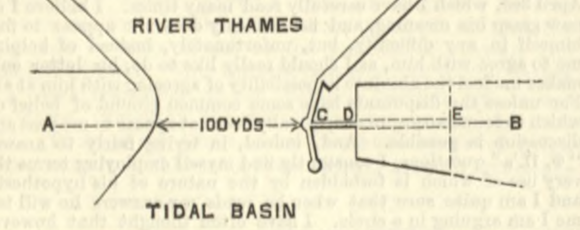
SIR,—When drawing a comparison, in his letter of the 15th ult., between the original plans of these docks and the plans now being carried out, it would have been well if your correspondent "Z." had noted that whereas the original scheme, according to the figures published by you on the 23rd September, 1881, was estimated to cost £1,096,000, the works are now to cost—according to your correspondent, "W. X. Y.," who, doubtless, speaks on good authority—"some £2,000,000." One would have been prepared to hear of a considerable increase; but the increase from 1,000,000 to 2,000,000 is astounding.

Scarcely less astounding is the testimony of the eye-witness "Forth," in your last week's columns, as to the ballast for concrete being "very dirty" and "only turned over once dry and once wet." What can be expected of ten to one or any other concrete under such conditions? This is a very serious matter.

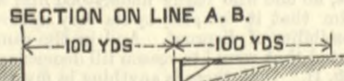
Again, whilst your correspondent "W. X. Y." speaks of "the very soft nature of the excavation," "Forth" says he saw "the excavation in the middle of the dock standing in some parts with an almost vertical face." The significance of the almost vertical face depends, of course, upon the height of the stratum which was seen to stand, its level, the extent to which it had been drained, the length of time it had been standing, the conditions of the weather during such time, and so on. Probably "Forth" was speaking of a small section, whereas "W. X. Y." speaks generally.

Having regard to the very great depth of water in the docks and the "very soft nature of the excavation," the question is rather, how long will even the six to one slopes be able to stand? This question of the slope would seem to affect the design for the entrance, which, as your correspondent "Z." says, shows a "curious state of things." The steamer shown in your bird's-eye view, with its stern close to the north-west corner of the Tidal Basin, must, I think, be wrongly drawn, for the works at the entrance, and the existence of the internal jetties in the Tidal Basin, show that the up-stream side of both the entrance and the Tidal Basin will be sloped, and not walled.

PLAN



SECTION ON LINE A. B.



Assuming that the solid lines in the annexed sketches are fairly in accordance with the particulars you have published; then if the ground really requires a six to one slope, as it seems to do, the bridge, instead of extending from C to D, will have to extend to E, making the entrance as a whole more extraordinary still.

"Forth" suggests that "in the event of an accident occurring to the lock, or any repairs being required to the gates, &c., the lock can be pumped out." It is difficult to see how the water from the Tidal Basin would be kept out, the gates opening inward.

May 18th. THAMES.

HYDRAULIC LIFTS.

SIR,—The number of letters, requesting copies of our pamphlet, which have been received by us since the publication of our last letter in your paper, attest the interest which has been excited by our discussion with Mr. Ellington. We had considered the argument closed, but are reluctantly obliged to address you yet once more, after reading Mr. Ellington's letter in your last issue. It is true it contains no new matter, but it might lead to erroneous conclusions if allowed to pass without notice by us.

When Mr. Ellington says that "steam lifts for passenger use were practically abandoned in England twenty years ago in favour of low-pressure hydraulic lifts worked from tanks," he, of course, is to be understood as meaning the kind of steam lifts then used in England. No doubt his statement is perfectly correct, but it has no reference whatever to the Otis steam lift, which has never been seen in this country, and consequently never abandoned.

We notice next the paragraph in which Mr. Ellington says: "I take it from the American Company's letter that it was about six years ago that Otis Brothers issued a circular stating "that they were at last convinced that hydraulic lifts were as good if not better than steam lifts." There is no ground whatever for this statement. It is purely an assumption of Mr. Ellington's. No such circular was ever issued. On the contrary, they continued to make their Otis steam lifts—not steam lifts generally—because no hydraulic lift was found so good, until the Standard was invented, and proved to be better even than the Otis steam lift.

The argument involved in Mr. Ellington's question, "Why should 160ft. head be desirable and 1600ft. disastrous?" might be carried a little further. 1600ft. head would be about the pressure —700 lb.—at which the Power Company supply their water; and we might just as fairly ask why they should not take 1600ft., or 7000 lb., instead of 700 lb. We have given in our previous letters the facts and reasons why we work at the low pressure.

The statement that "there is no peculiarity in the details of the construction of the American lift which will save it from the same fate as other lifts worked on the same system of low pressure," must also be denied. It is the fact of just such a "peculiarity in the details of the construction" which has given us our great success, and which is admitted by every one who enters upon a dispassionate examination of our lift. The working model in our office will prove this. AMERICAN ELEVATOR COMPANY.

38, Old Jewry, E.C., May 19th.

THE HEBERLEIN AUTOMATIC BRAKE.

SIR,—In the parliamentary return on continuous brakes for the six months ending 31st December, 1884, it is made to appear as if the present Heberlein brake, as in use on the Colne Valley and Halstead Railway, complies only in part with the requirements of the Board of Trade. Will you kindly allow me space to point out that the entry regarding these brakes was made under a misapprehension of the circumstances, and that by a letter dated the 15th May, 1885, we have been informed by the Railway Department of the Board of Trade that in any future returns these brakes shall be entered in the first class of the abstract, or as complying with all the requirements? CHARLES FAIRHOLME.

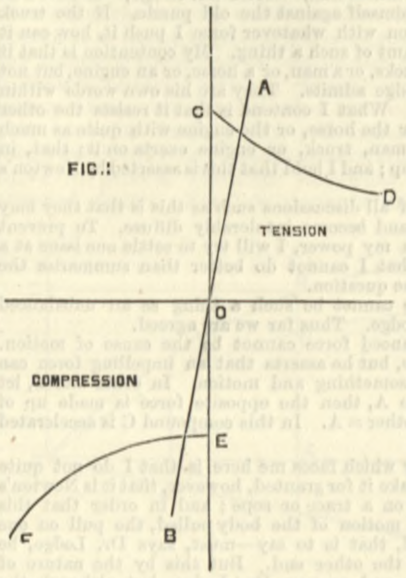
18, St. Dunstan's-hill, London, E.C., May 18th.

STRESS AND STRAIN DIAGRAMS.

SIR,—Professor Kennedy and Professor Pearson have asked in *Nature* that other experimenters should assist them in fixing a mode of speaking of the phenomena which occur when a solid bar is tested to fracture. The manner of yielding of the bar has now for several years been commonly represented in a stress and strain diagram, and in some testing machines this diagram is drawn autographically. Such an autographic diagram is a continuous record of the phenomena in testing, and forms, therefore, a convenient basis for discussing them. It is most convenient, however, and certainly more usual, to draw the diagram not as Professor Kennedy does, but with the strains for abscissæ and the loads or stresses for ordinates.

In a perfectly elastic material the stress and strain curve is a straight line *a o b* passing through the origin—Fig. 1. For a perfectly plastic material, and for loads above that which induces the plastic state, it is easily shown that the stress and strain curves are lines such as *c d*, *e f*, but they start from loads O *c*, O *e* necessary to induce the plastic state. For the compression curve the compression increases with the load; but for the tension curve the extension involves a diminution of section, and therefore a decrease of load.

FIG. 1.



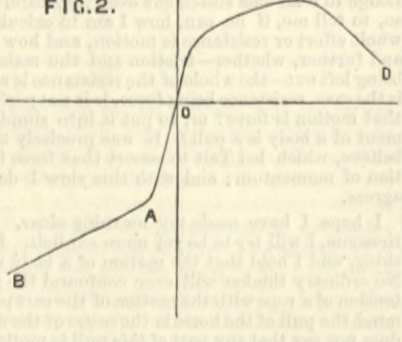
For an elastic bar, as is well known, the relation of the load P to the deformation λ is given by the equation P = K λ. For a plastic bar, from the sensibly constant volume V and the constant stress *f*, we get for the load corresponding to a deformation from an initial length l to a length $l \pm \lambda$

$$P = P_1 \frac{l}{l \pm \lambda}$$

where P_1 is the load corresponding to the length l. The + sign corresponds to the tension, and the − sign to the compression case.

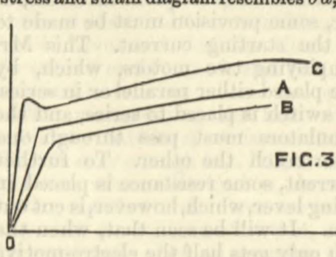
Now, it is generally known that with many materials, the first part of the stress and strain diagram agrees pretty closely with a straight line, such as *a o* or *o b*. I do not know that it has been pointed out that the latter part of such a diagram corresponds with a plastic curve such as *c d* or *e f*. If the compressions of a short wrought iron cylinder are plotted for loads increased up to a point far beyond the elastic limit, we get a curve like *o a b*, Fig. 2, and the part *a b* corresponds to a plastic curve. Professor Cotterill has already shown that in the case of short cylinders of this kind loaded beyond the elastic limit the stress per unit of area varies but little, so that the cylinder behaves as a plastic material. But again, in tension tests of ductile material, especially when the stress strain diagram is drawn autographically, we get a curve like *o c d*, Fig. 2, where the part *c d* corresponds to a plastic curve.

FIG. 2.



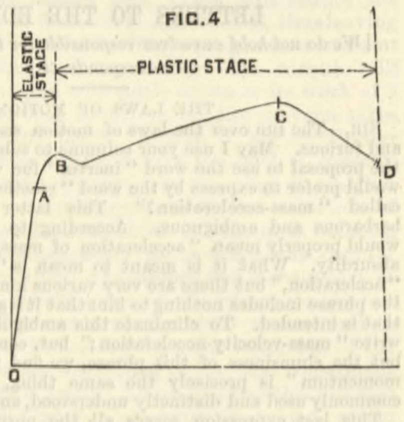
The laws of plastic yielding have been studied by Tresca, and it seems right to preserve the name for phenomena of this kind given to them by the most authoritative writers in this country. Plasticity, as defined by Thomson and Tait, is the property of experiencing under continued stress either quite continued and unlimited change of shape, or gradually very great change at a diminishing rate through infinite time. There is, therefore, during the test of a ductile material, an elastic and a plastic stage, the one passing into the other by a more or less gradual change, during which the material is imperfectly elastic or imperfectly plastic.

With some materials, and only, so far as I know, with materials which have been hammered or rolled while hot, there is, a little beyond the elastic limit, a very marked and singular jump in the stress and strain curve. Professor Kennedy described this, calling it the breaking-down point, in 1881, but it had been still more accurately described by Bauschinger in 1879, his experiments being dated 1877. To a certain extent the existence of this point was known from a much earlier period; but the great suddenness of the increase of extension, lateral contraction, and temperature was first quite clearly indicated in Bauschinger's paper. The phenomenon of a breaking-down point is not due to any action of the testing machine, for it is shown in diagrams from a machine in which the load is automatically adjusted to the resistance of the bar. I believe the breaking-down point is a kind of geological record of the state of stress in the bar at the moment of rolling or hammering; not that the stress in rolling is identical with the stress at the breaking-down point, for the influence of the difference of temperature has to be allowed for. If a bar is tested up to a stress at which it is partially plastic, and then re-tested, the stress and strain diagram resembles *o a*, Fig. 3. Up to the load previously imposed, the line is straight and the material perfectly elastic, beyond that point the plastic yielding begins again, and a sharp cusp marks the transition. If a bar is cold rolled the curve is like *o b*, the more gradual curvature being due, I think, to the fact that the different layers of material are acted on differently in rolling, and the rigidity of the layers is broken down successively in testing. But in a hot rolled ductile bar the curve is like *o c*, a quite sudden breaking down marking the point at which the rigidity due to rolling is overcome.



Next to the breaking-down point, the most important point to observe in practical testing is the point *c*, Fig. 2, where the maximum load is reached. Some day engineers will cease to pay any attention to what happens to the bar when the point *c* is passed. For this point it would be very convenient to have a name, and by analogy with elastic limit—limit of perfect elasticity —I would suggest "plastic limit"—limit at which the material near the point of fracture becomes perfectly plastic. Consequently in the complete diagram I should distinguish thus, Fig. 4. From O to *b*, elastic stage —from O to *a*, perfect; from *a* to *b*, imperfect; from *b* to *d*, plastic stage—from *b* to *c*, imperfect; from *c* to *d*, perfect; *a*, the primitive elastic limit; *b*, the breaking down point; *c*, the plastic limit; *d*, the breaking point—of no particular importance.

FIG. 4



It may be well, finally, to examine some actual diagrams plotted to scale, though not all to the same scale. Fig. 5 gives some compression diagrams. O *a* and O *b* are compression diagrams for cast iron. There is strictly no elastic limit, though the early part of the diagram is nearly straight. The material never becomes very plastic. Hence the curve might be described as showing imperfect elasticity throughout. O *c* is the diagram for a wrought iron cylinder, and shows a well-marked plastic stage.

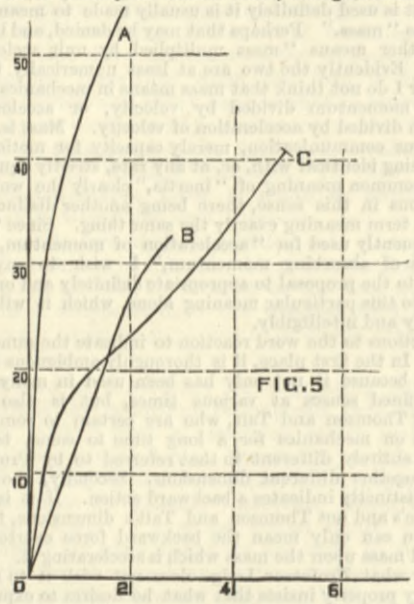


FIG. 6.

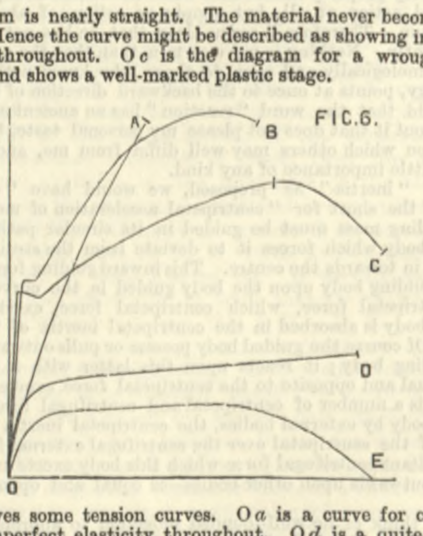


Fig. 6 gives some tension curves. O *a* is a curve for cast iron showing imperfect elasticity throughout. O *d* is a quite similar curve for brass, in which, however, the later part of the curve shows greater plasticity. O *c* is one of Professor Thurston's curves, with a well-marked perfectly plastic stage. O *b* is an American autographic curve for steel, and O *e* a curve from Buckton's autographic apparatus. In both these the elastic stage and plastic stage are well marked. W. C. UNWIN.

May 18th.

PROFESSOR A. HERSCHEL ON THE EFFICIENCY OF FANS.

SIR,—The tracing-out of force that is latent, and yet retains all its power, is very attractive to any one living amongst Eastern mysticism, and the letter of Professor A. Herschel, in THE ENGINEER for December 26th last, is evidently meant as an introduction to the search men of science must, in the long run, make into the nature and direction of the forces that are not yet understood, but which none know better than Professor Herschel do exist.

The terms used by most of us to express force are, as Professor Herschel points out, somewhat indefinite, and the books, in stopping short at the energy of a particle $\frac{W}{2g} v^2$, instead of $\frac{W}{2g} v^2 + W h$, the full value of the "motric and barometric heads together," do not really give the constant source of moving matter's mechanical activity.

The demonstration of the energy of a particle of moving fluid without friction in Rankine's "Applied Mechanics," p. 569, Articles 618 to 622, is lengthy to quote, but the principle is much more simply to be inferred from Art. 557, p. 503, where the energy of the particle of a fluid at any point must be that due not only to the height from which its own weight has fallen, but in overcoming resistance to the pressure of all the particles in the upward row immediately behind it, or the total amount of its energy is $\frac{W}{2g} v^2 + \overline{W} h$, as a mathematical expression.

It is exceedingly difficult to fix the mind on what energy is, and the difference between "energy" and "momentum." One of the most singular properties of matter, and where the occult at one point links on, is that a substance may be combined with immense energy, and yet be absolutely unaltered in structure to all appearance, and even motionless. It is so in two ways, either as combined with $\frac{v^2}{2}$, or with $g h$. In this partially is the difficulty of the subject, and where lectures and instruction by professors are so much required. $\frac{W}{g}$, it has to be noted, is the weight, so to say, of a body, irrespective of gravity; and $\frac{W}{g} \times \frac{v^2}{2} + \frac{W}{g} \times g h = \frac{W}{2g} v^2 + \overline{W} h$.

There is a theorem, p. 499, Art. 549, of Rankine's "Applied Mechanics," which would, in a way extremely easy to follow, show that the increase of actual energy produced by an "unbalanced effort" is equal to the "potential energy" exerted—that is, coming into play. The meaning of this is, that at a closed orifice a particle of fluid is at rest with a certain potential energy; but directly it is allowed to escape, the power it is capable of exerting against resistance, or its "total energy," is equal to the "potential energy."

Just to run through the proof, the "mass" is $\frac{W}{g}$ as before, and this is acted on by a force P equal, say, $\frac{W}{2g} v^2 + \overline{W} h$, and experiences resistance R, which leaves it, of course, equal to nothing when the orifice is shut. Directly it is open, the particle is urged by an "unbalanced effort" P − R, and suppose the head kept the same for simplicity, and this effort therefore constant. Then the particle is uniformly accelerated, and if its velocity at the beginning of a very short time $d t$ is $\overline{V}$, and at the end v, the increase of the particle's momentum is $\frac{W}{g} (v - \overline{V})$, which is equal to the work done by the unbalanced effort during the time; or $= (P - R) d t$. But the mean velocity of the particle during the infinitesimal time is $\frac{v + \overline{V}}{2}$, and the distance the particle has gone is $\frac{v + \overline{V}}{2} d t$ (feet a second by time), or $d s = \frac{v + \overline{V}}{2} d t$.

Multiply $\frac{W}{g} (v - \overline{V}) = (P - R) d t$ by $\frac{v + \overline{V}}{2}$ this mean velocity, and we have

$$\frac{W}{2g} (v - \overline{V})(v + \overline{V}) = (P - R) \frac{v + \overline{V}}{2} d t = (P - R) d s,$$

when $d s$ is the distance, or $\frac{W}{2g} (v^2 - V^2)$

the particle has travelled in the infinitesimal time, multiplied by the excess of the pressure or its total energy over resistance. Except that $(P - R)$, $d s$ conflicts with Rankine's definition of potential energy, that it "is measured by the product of the effort into the distance through which its point of application is capable of being moved," the proof would be complete; but the quantity is really work done, as the distance $d s$ has been actually traversed, or there would have been no mean velocity.

It is difficult to see from where any energy in excess of $\frac{W}{g} \times \frac{v^2}{2}$ can be obtained from the impact of the particles of a fluid. The halving of $\frac{W}{g} v^2$ comes from the area of a triangle made up of lines that represent the distances that in successive short intervals of time a particle falls by means of the force g of gravitation. Had the particles of matter oscillatory or rotative proper motion, which, in fact, all—as is attempted to be shown in the writer's pamphlet, "Darkness in the Land of Egypt," London, Edward Stanford—have, and this were simultaneously converted into translatory motion, it would be different, and the triangle of gravitation, a quiet conformable figure, would be blown, as in explosion, into one that is incalculable and monstrous. Here, again, Professor Herschel brings his argument to the occult boundary.

The instance of the fitting of a short tube having a bell-mouthed opening to a jet of water causing a coefficient of discharge greater than unity, instead of the usual 0·65 in the *vend contractâ* for the same head, hardly reveals any source of hidden power. It must be really, that, while the ordinary opening of the jet lessened the potential energy $\overline{W} h$ by the conflict of particles, an improved adjutage directed an almost straight descent, and gave $\overline{W} h$ a maximum of value: so that the new *vend contractâ* was the actual largest possible contracted vein due to the area of a section of the falling particles, and the height through which they had to fall.

There is, however, as every bicycle rider must experience, a form of force, "deviating force;" and the rate of deviation is expressed by $\frac{v^2}{r}$; v denoting the velocity and r the radius of curvature of the path of a particle in an infinitesimally short time. So that if v is the velocity of a particle in a straight line, $\frac{v^2}{r}$ represents the ratio of the curved path actually taken to the length of the straight line that would otherwise have been taken. This means "mass" into "distance," or extra work done, $\frac{W}{g} \times \frac{v^2}{r}$, in a direction at right angles to the original direction of the particle. Deviating or centrifugal force can therefore, unlike gravitation's force in one direction only, be expressed in the ratio $\frac{v^2}{r}$. The force can be brought into action without affecting the value of v in the least; and if r, the radius, is very small, the distance to which the moving particle or moving body can be pulled with its full velocity unchanged out of its path is considerable. And this part of the subject can be further pursued in Rankine's Theorem, p. 507, Art. 564, that "the actual energy of a system of bodies relatively to an external point is the sum of their actual energy, as referred to their own centre of gravity, added to the actual energy of the whole system, calculated from the velocity of the centre of gravity, with respect to the external point."

The toy bandelier, alluded to by Professor Herschel, illustrates what Rankine laid down at p. 503, Art. 557, that "the total energy of a body is the sum of its potential and actual energies." The bandelier falling, and acquiring increased momentum, turning on the string when it has reached it fullest momentum, and rising to unstable rest again, has performed no work, though it has moved, beyond moving itself to a place where its potential energy is greater. What has occurred has been a constant mutual interchange in the values of v and h in the formula $\frac{W}{g} \times \frac{v^2}{2} + \overline{W} h$; one getting greater as the other got less, and reciprocally; but at any instant the spool has been capable of doing the full amount of work against resistance, though not in the same time, at every instant of its course.

Here, again—and it is time to end—Professor Herschel has brought the impalpable element of time into the discussion; and not only can a substance have velocity without its structure being conceivably disorganised, but likewise be affected by time, without bearing any trace of time's action. Of course if there is heated air at the bottom of the shaft of a mine having a tendency to rise, and cold air at the surface of the ground with a tendency to fall, a fan up to a certain velocity excites a current without doing any work except opposing friction.

A. T. FRASER, Lieutenant-Colonel R.E.

India (Madras Presidency), March 27th.

THE THEORETICAL EFFICIENCY OF THE STEAM ENGINE.

SIR,—Assuming permanent gases to consist of particles absolutely free from any attractive or repulsive influence, it it quite clear that any work derived from their expansion must be merely a part of the work initially contained in the gas in the shape of energy of motion; and as the absolute temperature represents nothing more nor less than the quantity of energy thus stored in the gas, it follows evidently that the proportion between the fall of the absolute temperature, in work-producing expansion, and the initial absolute temperature represents the efficiency of the fluid—that is, the proportion in which the heat contained in the fluid is converted into work during the given expansion. That the absolute temperature of a permanent gas represents the mechanical work contained by the gas is proved by the fact that air, which approaches very nearly to the hypothetical conditions of a perfect gas, has a constant specific heat independent of pressure or volume of temperature. When air is compressed, heat is developed in quantity proportional to the work expended in the compression; when it is expanded doing work, the air cools proportionally to the work done, and when it expands without doing work the temperature remains unchanged. These phenomena prove that in the case of air the absolute temperature represents the contained energy, and that that energy is wholly in the shape of motion of the particles. When we say therefore that the efficiency of a reversible heat engine—reversible, that is, an engine in which no free expansion takes place—is proportional simply to the fall of the absolute temperature between the heater and the cooler, we assume that the absolute temperature represents the whole contained energy in the fluid at any time. In the case of steam this assumption is not justified. The quantity of heat contained in steam is not simply proportional to its absolute temperature, as is the case with air. The experiments of Siemens proved that the free expansion of steam superheats it—a result to be expected, considering that the total heat of steam increases with the pressure; there is therefore an excess of heat in the freely expanded low-pressure steam, and that excess must necessarily superheat the steam. This circumstance, opposed to the fact that the free expansion of air does not change its temperature, points forcibly to the unfairness of applying to steam the criterion of efficiency adapted to permanent gases; in the latter, absolute temperature and mechanical work are almost interchangeable phrases; in the former, the temperature changes mechanical work. The temperature of a given mass of air can be lowered only by taking away heat or mechanical work. The temperature of steam, on the other hand, is lowered by its simple free expansion without either loss of heat or development of mechanical work. Of course the difference depends upon the fact that in steam there is an interaction of some sort between the particles, which gives rise to what has been termed internal work; but nevertheless, the fact is too often lost sight of in the praiseworthy effort to simplify theories and bring them within the grasp of the million. In an excellent recent manual of marine engineering, the efficiency of the steam engine is given as dependent in great measure on the limits of temperature between which it works—the ordinary temperatures of Fahrenheit's scale. It is to be hoped that the book promised by Mr. MacFarlane Gray will clear up the intricate ground about the second law of thermo-dynamics as applied to actual working fluids; it is clear enough when limited to permanent gases.

ROBERT GILL.

Palermo, April 23rd.

STRESSES ON ROOFS.

SIR,—In a flat timber roof the rafters are united at about half their length by a collar beam, so that each pair of rafters resembles with the collar beam a letter A. Now, under certain conditions, this collar beam is a strut; under others it is a tie. For example, if the walls are too weak to bear the thrust of the rafters, then the collar beam will act as a tie. I have a roof now in which the collar beams act thus. If the walls are strong enough to stand the thrust, then the collar beam acts as a strut. I have roofs in which it is so acting.

Now, I want to know, if, when the side walls are weak, and it is acting as a tie, the strain on the collar beam is not less than the apparent tensile strain by the amount which would compress it if the walls were strong. This compression is due to the weakness of the rafters, and if these were strong enough, there would be no compression. Will any of your readers kindly tell me how to arrive at the proper proportions to adopt under any conditions? I am quite at sea, and I can find no allusion to the question in any work on stresses in roofs that I have been able to consult. To the authors of these books a tie is a tie and a strut is a strut, but surely there must be conditions under which, with wooden roofs at all events, which deflect freely, a member may act in one sense both as a tie and a strut at the same time. Some time ago I saw a barn roof of the kind I have named in which some of the collar beams were in tension and others were buckled up by compression, and this in the same roof. Again, what is the proper height to put a collar beam at? We are not quite done with wooden roofs yet, and some information on the subject would be greatly appreciated by a puzzled

Bath, May 13th. FOREMAN CARPENTER.

THE DEAD-WEIGHT CRUSHING MILL.

SIR,—In your notice of the above machine, contained in your excellent issue of the 8th inst., you say you are informed "that it requires with this machine one-third the power of disintegrators for doing the same amount of work." My experience, extending over fifteen years, exclusively devoted to crushing and grinding machinery, should be worth something to the public, and, confining myself to the question of treating coal, I can emphatically say that such a mill cannot deal with one-third the quantity of coal that a medium-sized disintegrator would in the same time, whether wet or dry; that it is utterly impossible for the dead-weight system of crushing to prepare coal so efficiently as the percussive system, nor will the resulting coke be of the same quality from the same coal.

The question of power has little to do with it; it is a question of useful effect for a given power. My disintegrators are in use, and have been some time, grinding wet coal as it is delivered from the washing machine, and I shall be happy to test one of my machines at any time against the dead-weight crusher, for the benefit of the coal trade, to set at rest this vexed question, if Messrs. Sheppard will enter the lists upon equal terms.

There is nothing novel in carrying heavy rolls upon suspended or pivotted arms. I have made mills on this principle which weigh upwards of 30 tons, and are now at work, but I should hardly dream of applying them to the question of coal-grinding after my experience with disintegrators.

I trust you will favour me with the insertion of this letter in an early issue. CHAS. E. HALL.

Standard Ironworks, Sheffield, May 11th.

BOILER EFFICIENCY.

SIR,—As a member of a manufacturing firm, who are extensive users of steam power, I was much interested in a letter signed "Economist," which appeared in THE ENGINEER of April 24th. I had hoped that some correspondent of "light and leading" would have favoured your readers with their or his opinion on such an important subject. As they have not done so, I beg leave to ask one or two questions on the subject through the medium of your valuable journal.

First, is it a fact that a very large proportion of the heat known to be lost is occasioned by the air necessary for the combustion of the fuel being supplied to the furnace by the action of a chimney draught? Secondly, can this loss be avoided by the use of the simple apparatus described by "Economist?" Thirdly, if so, are we justified in wasting the wealth of the nation and depriving posterity of one of the first necessaries of life by wasting coal at the rate of ten or twelve million tons yearly, and increasing the cost of British manufactured goods, so as to render us unable to compete with the foreigner in many markets of the world?

The importance of this subject must be my apology for thus trespassing on your valuable space. THOS. RAYBOULD.

Edgbaston, Birmingham, May 19th.

MADAN'S INJECTORS.

SIR,—While thanking you for the very kind notice of my exhibits at the Inventions Exhibition in your issue of May 8th, I should be greatly obliged if you would, by inserting this, remove a false impression which might be created by it. The article is headed "Borland's Injectors," while the greater part of it is devoted to a description of the "Vortex" steam jet pumps and the "Mansfield" injectors, which are respectively my own patent and design. I purchased the patent rights of the injectors known in the market as "Borland's patent injectors" some time ago, and have since improved them, and they form the more important part of my exhibit, as a number of them are fitted to Messrs. Davey, Paxman, and Co.'s boilers in the electric light shed. The fact that I am the proprietor of Borland's patent injectors is the only connection between them and the first-mentioned instruments.

Mansfield-chambers, St Ann's-square, CHARLES S. MADAN.
Manchester, May 14th.

LAUNCHES AND TRIAL TRIPS.

THE trial trip of the Isle of Man steamer Snaefell was made on the 13th inst., after the renewal of her boilers and partial renewal of her engines. The result is that, indicating some 2000-horse power, she performed the trip—Douglas to Liverpool—under four hours and a-half.

The steamer Ching Woo, built by Messrs. Raylton Dixon and Co., left Middlesbrough Dock on the 15th inst. on her trial trip. Her leading dimensions are 332ft. over all × 38ft. × 27ft. depth moulded. She is built on fine lines, and will have a carrying capacity of over 4100 tons of tea. We have already given other particulars of this vessel. Her trial trip, which, as before-named, took place on the 15th inst., proved in every way satisfactory. The engines, which work direct on three cranks, are very steady in movement, and worked without the slightest hitch, and gave a speed of 12½ knots, which, we are informed, could be maintained with the greatest ease.

On Saturday, the 16th inst., Messrs. Schlesinger, Davis, and Co., Wallsend, launched an iron screw yacht, named the Salamander, of the following dimensions:—Length over all, 130ft. 6in.; breadth, moulded, 20ft.; depth of hold, 10ft. 6in.; yacht measurement tonnage, 211 tons. She is built with a clipper stem and figure-head, and a square stern with long overhang. She is constructed on very fine lines, and is expected to travel at a good rate either under steam or sail. The vessel has been constructsd under special survey, and will be classed in Lloyd's Yacht Register, her scantlings being in most cases considerably in excess of Lloyd's requirements. She is built for Mr. Frederick Power, of London. The yacht will carry four boats, one of these being a steam launch. She will be fitted with a direct-acting steam windlass by Messrs. Harfield and Co. Messrs. Davis and Co.'s patent steam steering gear will be placed on the deck-house. It is intended to light the vessel throughout with electric light, but owing to the delay with the electricians, the Salamander will probably cruise this season with the ordinary lamps. She will be rigged as a topsail schooner and will carry a large spread of canvas. The engines are on the Perkins system, with triple expansion, and a working pressure of steam of 500 lb. to the square inch; and it is expected they will develope great power on a very small consumption of fuel. The sizes of the cylinders of the Salamander are 7¾in., 15$\frac{1}{16}$in., and 22⅞in. diameter, with a stroke of 15in.

On May 16th the steamship Eldorado, built and engined by Messrs. Earle's Shipbuilding and Engineering Company, Hull, for Thomas Wilson, Sons, and Co., was taken on her trial trip on the measured mile off Withernsea. The vessel is classed A1 in the Liverpool Registry. Her dimensions are: Length, 235ft.; breadth, 30ft.; depth of hold, 15ft. Being intended exclusively for passenger traffic, she is designed with very fine lines, and the utmost available space has been set apart for passenger accommodation. She has a long, full poop and topgallant forecastle, the engines being placed as far aft as possible. The whole of the first-class accommodation is thus provided forward of the engines and boilers under the poop. A large iron deck-house is fitted on the poop, containing saloon entrance, music, smoke, and chart rooms, and wheel-house, and the top of this, together with the poop deck, will afford a spacious promenade. The whole of the ship is lighted by electricity. There is sleeping accommodation for eighty-six first-class passengers. The watertight bulkheads have been constructed so as to ensure the safety of the vessel, as far as possible, in the event of collision. The collision bulkhead is designed of a conical form, and is unusually strong, in order to resist pressure in case any damage is done to the bow. A small water-ballast tank is fitted forward for trimming the ship, and she is rigged as a schooner, with three pole masts. The 'tween decks forward will be arranged for carrying emigrants. She is fitted by the builders with their triple compound three-crank engines, of 300 nominal horse-power, having cylinders 26in., 40in., and 68in. diameter, and 39in. piston stroke, supplied with steam of 150 lb. pressure from two large steel boilers, each fitted with four of Fox's patent corrugated furnaces. The speed attained on the measured mile was, we are informed, 14·43 knots, notwithstanding the rough state of the weather. It it expected that, under more favourable circumstances and in better trim, she will steam about 15 knots. The Eldorada leaves Hull for Bergen on the 26th inst., on her first voyage.

On the 16th inst. a steel paddle-wheel steam launch, 65ft. long, by 11ft. broad, and 18in. draught of water, lately launched by Messrs. Matthew, Paul and Co., Dumbarton, and built and engined by them for Messrs. P. McIntosh and Sons, Glasgow, for the Indian Government, under the superintendence of Messrs. MacNicoll and Co., consulting engineers and naval architects, Glasgow, went on her official trip with a large party of ladies and gentlemen on board. Owing to the rough weather, it was not thought advisable to go to the Wemyss Bay measured mile with such a light draught craft, having only open bulwarks; but her power and speed were abundantly shown on the way to the Gareloch, against a strong head wind and heavy sea. The engines are fitted with Messrs. Paul's patent valve gearing and reversing motion.

SOUTH KENSINGTON MUSEUM.—Visitors during the week ending May 16th, 1885:—On Monday, Tuesday, and Saturday, free, from 10 a.m. to 10 p.m., Museum, 9307; mercantile marine, Indian section, and other collections, 3614. On Wednesday, Thursday, and Friday, admission 6d., from 10 a.m. to 6 p.m., Museum, 1528; mercantile marine, Indian section, and other collections, 134. Total, 14,583. Average of corresponding week in former years, 14,738. Total from the opening of the Museum, 23,997,849.

AMERICAN NOTES.

(*From our own Correspondent.*)

NEW YORK, May 9th.

DURING the past week contracts for 30,000 tons of rails have been placed at prices ranging from 26 dols. to 27 dols. Rumours are rife of contracts having been placed at lower figures. The Pennsylvania mills are well supplied with orders for the next ninety days. The distribution of manufactured product appears to be improving slowly. The chief source of demand, however, viz., the railroads, is wanting. Within a week or two a number of important enterprises have been announced, among which are the following:—600 miles of road through Kansas to Denver, Colorado; a forty-five mile road from Missouri into Nebraska; two new roads in Georgia to connect Chattanooga with the Gulf by way of Rome. Contracts have been placed for the construction of a New York and Omaha Road. A road is to be built from Grand Rapids, Michigan, to Lake Superior; a sixty-five mile road from Port Perry, Western Pennsylvania, to Punxcutawny. If the material for these roads will be contracted for during the next sixty days, as is anticipated, it will have a favourable effect upon trade and prices, and will impart a stability which rail makers have been predicting will be felt. There is an abundance of capital, but a lack of confidence. The railway traffic is below the normal limit. Investors and builders are postponing many enterprises on this account. The first evidence of genuine improvement will develope a great deal of waiting enterprise, and it is in view of this probability that several large buyers have recently been placing contracts, and are now negotiating for steel during the summer and autumn. The Engineers' Clubs of St. Louis and Philadelphia and the Western Society of Engineers have recently held important and interesting meetings, at which questions of great engineering interest were discussed. Among them was the best means of avoiding the breaking of shafts; a discussion on defective bridge building. The Western Society of Engineers have arranged for the exchange of transactions between their association and the Liverpool Engineering Society. Our Chamber of Commerce looks for a year of gradual revival, and a full restoration of value to every real security and commodity, and states that already there is a healthy revival of trade in many branches, domestic and foreign, but admits that activity in securities cannot be expected until their real value is ascertained. The Chamber thinks that the present depression will gradually give place to the revival of those industries now very seriously affected. It says that the growing processes, increased consumption, arising from the rapid rise in population, will restore activity to every branch of the trade, and rejoices over the fact that the balance of trade is in our favour by the first quarter of the present year is in the neighbourhood of 10,000,000 lb. The exports of coin have exceeded imports by 500,000 lb., of which 80 per cent. was silver. The commercial interests are intently discussing the best means of securing a portion of the South American commercial traffic, but while there is an earnest desire for more intimate commercial relations, no definite or practical plan is proposed. The receipt of cereals from the North-west is heavier than during any year in our history, being 30 per cent. in excess of last season. The depression in prices has thus far had a favourable effect upon the agricultural interests, and a less area has been subjected to cultivation this season. The cotton growers are looking forward to a very heavy crop and a more active demand for it.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(*From our own Correspondent.*)

BEYOND the placing by merchants of export orders previously withheld, it would not appear that the iron market here has much benefitted by the unravelling of foreign complications. Indian and Australian orders have been distributed with more freedom, and trade with South America is maintained, but British North America keeps unusually quiet.

Sheet and bar makers are unable generally to announce increased sales. Some firms this—Thursday—afternoon, who depend mainly upon local consumers, reported orders slower. The supply is much in excess of the demand, and prices consequently suffer. At one time sheets were 25 per cent. above common marked bars, but this is not so now. Sheets have been sold during the week on the basis of £6 15s. for galvanisers' singles, but the larger firms still uphold the £7 minimum, which is 10s. per ton under the marked bar basis. Doubles are quoted £7 5s., and lattens £8 to £8 5s. Stamping sheets, both of iron and steel, keep in good request by the makers of wrought hollow-ware and travelling trunks.

The American demand for the higher classes of bar iron has somewhat improved during the last fortnight, rivet and horseshoe iron being in better request. The official basis of £7 10s. is maintained; but the wide margin between the values of marked bars and the commoner qualities still prevails. It was as long ago as February, 1883, that marked bars were fixed at £7 10s. Ordinary bars are £6, and common, £5 10s. down to £5 5s. Occasionally hurdle bars may be had at £5 2s. 6d. Hoops are quoted £5 15s., but are selling at £5 10s. Hinge strip is quoted £6 10s., and supplies of gas strip of 6⅞in. widths are being secured at £5 5s. and upwards. Strips of 7in. to 8½in. are £5 15s. to £6, and of 8⅞in. to 12½in., £6 5s. to £6 10s.

Structural iron moves off at a regular rate. Angles of 1½in. to 4½in. are selling on the basis of £5 15s. to £6 5s., according to quality; and tees of ⅞in. to 2½in., £7 to £7 10s.

The Eagle Ironworks Hollingsworod Company, Oakengates, Shropshire, have closed their forge, and have discontinued making "until prices are such as will at least cover cost." The company is, however, supplying orders from stock.

The occurrence of the holidays next week, when very little will be done at the mills and forges, was used by manufactured ironmasters this afternoon, and yesterday in Wolverhampton, as an excuse for declining the acceptance of further deliveries of pig iron. Native makers and representatives of makers outside the district had no alternative but to acquiesce. Prices are not stronger. Hematites are changing hands at 53s., although 54s. is asked. All-mines are 55s. to 57s. 6d. nominal. Second-class pigs are 40s. to 45s., according to mixture, and although 36s. 3d. is asked for cinder qualities, 35s. is about all that can be got, and some sales are going on at 32s. 6d. Foreign pig prices are unchanged on the week.

Coal and other minerals are unimproved. Furnace coal is 8s. to 10s., and forge 6s. to 7s. per ton. Cokes show more vigour than ores, and coke vendors are pushing business. South Yorkshire furnace sorts are quoted 15s. delivered; Welsh, 14s.; and the Apedale, North Staffordshire, make, 13s. 9d. per ton.

Ironmasters point out the incongruity of the Millmen's Association as a body professing to protest against the new rate of payment introduced into certain of the sheet mills for rolling long lengths at the same time that some of the leading members of the Association have consented to work at the new scale. The threatened great strike of ironworkers in Pennsylvania from June 1st against reductions in wages said to amount to 20 per cent., is discussed with interest in some local circles this week. It is not thought, however, that it would have much effect upon the English iron market.

The girder yards in the district are fairly supplied with business, and the orders on the books are likely to keep the hands going for some considerable time.

Messrs. Cox and Co., engineers, West Bromwich, are building some powerful new winding engines for Messrs. Balfour and Co., colliery proprietors, who at their Oldfield Colliery, midway between Longton and Fenton, in North Staffordshire, have just recently made some important new coal discoveries. After two years' sinking the firm have struck the Yard coal, which is upwards of three yards thick, and also the Mossfield steam. Both are of excellent quality, and the new engine power is being put down to work them. Messrs. Balfour intend to increase their present output by 4000 tons a week, and the new engines, seconded by those which are now working, will be equal to raising from 6000 to 7000 tons a week.

Machinery engineers are not receiving much new work from Government. Still, a fair amount of work continues in hand at some of the large machinery workshops which has been received either from Government direct or from Government and naval contractors. Messrs. George Bellis and Co., Birmingham, who are very successful builders of light power marine engines for torpedo boats of their own designs, have just got out of hand a pair of engines of 1400-horse power for a torpedo boat, which is the largest yet constructed. Another contract upon which they are still at work is for five sets of machinery for new boats of this class, with engines of over 1000-horse power, and which will be capable of steaming quite 20 knots an hour. Messrs. Bellis have recently commenced the manufacture of compressed air reservoirs for supplying the motive power to torpedoes. The reservoirs are built up of nests of steel tubes calculated to withstand high pressure. Messrs. Tangye have, among other naval contracts under execution, one for twenty-four large centrifugal pumping engines for circulating water through the condensers of six of the cruisers now being built for the Government at Clydesbank.

The best export markets at date for the Birmingham machinists are India, Australia, and New Zealand. Makers of steam and hand power pumps find business better at the present time than two or three months ago, and in addition to the markets just mentioned, some of the South American Republics are buying pumps for mining and other purposes. The home demand is fair, but without any push.

The North Staffordshire iron trade is a little better this week in the shipping department. New Zealand and South America are among the buyers, and inquiries are rather more numerous from the Continent. The home demand continues poor, more especially for steel plates. Crude iron and ironstone show no revival. Prices for common bars are £5 5s. to £6; superior sorts, £6 10s.; and "Crown" qualities an average of £7; boiler plates are £8 to £8 10s.; and common plates £6 15s.

The demand for coal, both manufacturing and other kinds, is quiet, but no worse than for several weeks past.

The cable and anchor firms are experiencing a demand only sufficient to keep them going about four days a week, and then there is no pressure of work. The lower prices at which native makers are enabled to fill contracts for anchors and cables for use in Northern shipyards, compared with the prices asked by Tyneside cable and anchor firms, continues matter of interest. The apparent anomaly arises mainly from the circumstance that on account of the fibrous and ductile nature of Staffordshire iron, local manufacturers are able to use lower priced bars than the Northerners. The difference in price is 20s. to 30s. per ton in favour of Staffordshire, which, after deducting the 15s. per ton railway carriage, leaves a favourable margin as against Tyneside prices of the manufactured goods of 5s. or 15s. per ton—a margin quite sufficient in times like these to turn an order.

NOTES FROM LANCASHIRE.

(*From our own Correspondent.*)

Manchester.—The near approach of the Whitsuntide holidays, with the usual stoppages of works, naturally tends to give a quieter tone to trade. Consumers show a disposition to hold back from any buying beyond what they actually want for present requirements, whilst deliveries against contracts are also curtailed for the same reason. This, with the continued absence of any improvement in the actual condition of trade, has resulted in a very slow business being done during the past week, and both in pig and manufactured iron the tendency of prices is still downward.

Only a very small inquiry was reported in the Manchester iron market on Tuesday, and where business was done it was at extremely low prices. In the pig iron trade the only noticeable transaction was a tolerably large sale of Lincolnshire iron at a very low figure, the basis being 37s. 6d. for forge, and 38s. 6d. for foundry, less 2½, delivered equal to Manchester, which is probably the lowest point that has yet been reached. Local makers still hold to 39s. 6d. and 40s., less 2½, as their minimum price, and for the better class of district brands the quotations remain at from about 39s. for forge up to 40s. 6d. and 41s. for foundry, less 2½, delivered equal to Manchester. At these figures, however, makers are practically out of the market, and they are only got on occasional small lots for special requirements.

In hematites there has been some business doing at low figures, 51s. 6d. to 52s., less 2½, for foundry qualities delivered in the Manchester district, being about the basis at which orders for anything like quantities can be placed.

There is still only a very slow business doing in the manufactured iron trade, and inquiries that are put forward in the market lead to very little actual buying. The general feeling amongst buyers is that they are running no risk by waiting, and they only give out orders as they are absolutely compelled. For good qualities of Lancashire and North Staffordshire bars, £5 7s. 6d. remains the average quoted price for delivery into the Manchester district; but here and there a disposition is being shown to give way a little upon this figure, rather than allow orders to pass, and I have heard of as low as £5 5s. having been taken for North Staffordshire bars; but this has been for an exceptional specification.

The pressure of work which has recently been given out in connection with ordnance armour-plate and Government shipbuilding contracts has helped to make some of the heavy engineering branches in this district fairly busy. In heavy tools for the above class of work I may mention that Messrs. Collier, of Manchester, have completed a powerful machine for cutting off the bad ends of armour-plates, and also, when required, for cutting the armour-plates in two at any part of their length or width, or at any angle. The machine, which is adapted for the heaviest class of plates up to 18in. in thickness and 18ft. in length, consists of a massive foundation plate provided with T-headed grooves and slot and glut holes for cramping down the armour-plate. Upon this foundation plate is carried a powerful cross slide standing upon two feet, and this cross slide carries a movable head, upon which is a massive tool-box with vertical self-acting down feed, and adjustment horizontally by hand. The tool-box cuts one way only, but has a quick return. The head is traversed along the girder by a powerful double-threaded screw driven by spur gear from an internal wheel attached to the driving pulley. The total weight of the machine is about 25 tons.

Sir Joseph Whitworth and Co., of Manchester, in addition to the large quantity of Government work they have in hand, are very busy in their tool department, both on home and foreign orders. The bulk of the orders are, however, for abroad, and comprise tools for marine, locomotive, and general work. Amongst the tools they have in hand is a powerful planing machine in which the uprights are arranged to move and the work is held on a fixed bed, and a very large vertical boring machine for boring cylinders up to 120in. diameter.

Messrs. Whitworth, who have purchased additional land for the extension of their works, which will ultimately cover between 30 and 40 acres, have just completed for themselves a special lathe for propeller shafting. This lathe will take in work 62ft. long, and has been constructed to admit of the crank and shaft coupled up being put into the lathe complete. At present the lathe is being worked with two rests, but ultimately it will be fitted with four rests. It is very powerfully geared with steel gearing, and it has a very high strap speed. In addition to this tool, two other powerful lathes have recently been set to work, and others are in progress with 4ft. centres, and weighing about 150 tons. These are being specially erected for finishing the parts of guns and afterwards finishing the guns complete.

Messrs. R. and J. Dempster, of the Gas Plant Works, Manchester, have introduced an improvement in flattening rolls used for straightening iron and steel plates. In this machine a double set of powerful rollers is employed, the outer edge of the top rolls coming slightly below the level of the lower set. This gives a serpentine form to the plates as they are passed through the rolls, but they are delivered perfectly straight and ready for use without any hand labour in hammering out the buckles being required.

The Manchester Reception Committee, which has been appointed in connection with the approaching visit of the Gas Institute, has made arrangements for entertaining the members of the Institute at a *soirée* and ball to be held in the Manchester Town Hall on Wednesday evening, June 10th, and at a *conversazione* to be held the following evening in the Peel Park Museum, Salford. The other arrangements for the meeting, including visits to various works in the neighbourhood, are left in the hands of a committee appointed by the council of the Institute.

In the coal trade business generally is dull, and pits are getting on to less time. The demand for house-fire coals is still very fair for the time of the year, but the weight of coal moving away is decreasing, and at some of the collieries stocks are accumulating. For other descriptions of fuel the demand remains much the same as last reported; common round coals meet with a very slow sale for ironmaking and steam purposes, and are a drug in the market; engine classes of fuel are only in indifferent demand, and supplies are plentiful, especially of the commoner sorts of slack. There is no material change in the quoted prices, but the want of firmness is apparent, and where reductions have not already been made, there is in most cases a little giving way on the full list rates. At the pit mouth best coal averages 8s. 6d.; ordinary second qualities, 7s.; common coal, 5s. to 5s. 6d.; burgy, 4s. 6d. to 4s. 9d.; good qualities of slack, 3s. 9d. to 4s.; and common sorts, 2s. 9d. to 3s. per ton.

In the shipping trade there has been rather more doing, but the prices at which orders can be placed are very low, and good ordinary qualities of steam coal not averaging more than 6s. 9d. to 7s. per ton delivered at the high level, Liverpool, or the Garston Docks.

The reduction of miners' wages in the Manchester district amounting to about 10 per cent., of which notice was given at the commencement of the month, when the list prices of coal were reduced, does not seem to be meeting with any opposition on the part of the men, and work has not been stopped at any of the collieries in consequence of the reduced rate of wages being enforced. The coalowners in the Manchester district evidently manage things better than in Yorkshire.

Barrow.—There is a quiet tone in the hematite pig iron trade of Furness, and there is practically nothing new to report on the week. The demand for pig iron of all descriptions is very dull, and sales have lately been few in number and certainly inextensive. The inquiry for forwards is also without spirit, and the work in hand is not such as to justify hopes of an early improvement in trade. On the contrary, it is observable that makers are not able to dispose of more iron than they are manufacturing, and as a consequence stocks remain large. Prices are firm at late rates, showing, if anything will show, that the lowest practical point has been reached. Bessemer qualities of pig iron are quoted at 44s., 43s. 6d., and 43s. respectively for Nos. 1, 2, and 3, prompt delivery, net cash, with forwards 1s. per ton over these figures. The price for forge and foundry samples is given at 42s. and 42s. 6d. per ton. Steel makers have not booked many new orders, and their works are almost at a standstill. The business doing in the several descriptions of steel produced here is so quiet, indeed, that if change does not soon occur, there will be an even quieter summer trade than last, although the preparations for doing a brisker business have been made on all hands. Iron shipbuilders are busier, and are likely to be even more fully employed in the course of a week or two. Marine engineers remain especially brisk, and are working overtime on heavy contracts. There is no variation to note in the quiet tone of the iron ore trade, or in the firm attitude of the coal trade, while shipping, both as regards imports and exports, remains exceedingly dull.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

THERE are now distinct signs of the inevitable—the end of the miners' strike in Yorkshire. After the employers, as I anticipated, declared that the time has passed for arbitration, as the mischief was now done in idle pits and orders sent elsewhere, the miners again met in conference at Barnsley. Though reporters were excluded, and every effort made to keep the result a secret—the union secretaries even departing from their usual custom of making a communication to the press—the proceedings leaked out. A strong minority, it seems, was in favour of resuming work at the 10 per cent. reduction. This was negatived, but it paved the way for a kind of agreement that the difficulty should be referred back to the men. The result was that an informal ballot, or decision by public meeting, has been taken in several mining localities. At Thorncliffe, where over 3000 pit hands are employed, the example has been set of returning to work. The Thorncliffe Company—Messrs. Newton, Chambers, and Co.—has now got the majority of its colliers round to the reduction, and the minority will no doubt soon follow. At the Nunnery Colliery—some 1200 hands—the men still maintain a defiant attitude, but it is impossible for them to avoid following the action which is being taken by their brethren elsewhere. The strongest argument against further resistance is the fact that in spite of the stoppage of so many pits, and the compulsory idleness of 40,000 hands, the supply is still in excess of the demand, and the price is not materially increased anywhere, while in some quarters there is a positive falling off. The conclusion, of course, is that the market is having its requirements fully met by coalowners in other districts—notably, the North of England, from which fuel is brought readily by sea and placed upon the London market.

Messrs. Charles Cammell and Co. and Messrs. John Brown and Co., the two great armour-plate producing firms, are at present very busy in most of their leading departments, and several very important orders for the new armour-clads and cruisers of the Government have just been placed. These vessels were entrusted to private firms, who have now decided as to the production of the compound armour required for their armament. With Messrs. John Brown and Co., Atlas Steel and Ironworks, have been placed the armour for the two cruisers Orlando and Undaunted, to be built by the Palmer Shipbuilding Company, Jarrow-on-Tyne; one of the cruisers, the Australia, by Messrs. R. Napier and Sons, Glasgow; the cruiser Narcissus, by Earle's Shipbuilding Company, Hull; half the armour for the armour-clad Renown, by Sir W. G. Armstrong, Mitchell, and Co., Newcastle-on-Tyne. With Messrs. Charles Cammell and Co., Cyclops Steel and Ironworks, have been placed the armour for one of the cruisers, the Galatea, by Messrs. R. Napier and Sons; for the armour-clad Sans Pareil, by the Thames Iron Company, London; and half the armour for the armour-clad Renown, by Sir W. G. Armstrong, Mitchell, and Co., Newcastle-on-Tyne. The armour for the cruisers has to be delivered during the next sixteen months, and for the armour-clads during the next two years.

Messrs. Watson, Moorwood, and Company, of the Harleston Ironworks, have obtained the contract for cooking stoves and similar apparatus required by the Admiralty. The contract, which extends, over a period of five years, has usually been taken by London or Glasgow firms. This is the first time it has come to Sheffield.

Messrs. Ward and Payne, the largest edge tool makers perhaps in the world, report a good business in these articles with Spain, Germany, and Australia. The latter market, with South America, is also ordering freely in sheep shears. The United States' requirements in carvers' tools are important; but there is very little doing with the Cape markets, where business seems utterly demoralised. Spades, shovels, picks, and mining tools have been in better demand of late.

THE NORTH OF ENGLAND.

(From our own Correspondent.)

BUT little business was done at the Cleveland iron market, held at Middlesbrough on Tuesday last. Some consumers showed a disposition to buy forward, but they were not willing to give the prices asked by either makers or merchants. The demand for No. 3 g.m.b. for prompt delivery is but small, and sales have been made at as low a figure as 32s. 10½d. per ton. The usual quotation obtainable from merchants is, however, 33s. per ton for prompt, and 33s. 3d. for forward delivery; and except in rare cases less is not taken. Makers quote 33s. 6d. to 34s. per ton, and as most of them have orders on their books which will last for some time, they do not entertain lower offers. The demand for forge iron is somewhat easier, and small lots have been sold by merchants at 32s. 9d. per ton. Makers, however, continue to quote 33s.

There has been no change in the stock of Cleveland pig iron at Connal and Co.'s Middlesbrough stores during the past week. The quantity held is 50,242 tons.

The depressed state of trade on the Continent has of late seriously affected the shipments of pig iron from the Tees. Only 38,105 tons had been exported this month up to Monday last, as against 45,408 tons in the same period of May last year. During April the quantity shipped was 41,406 tons.

The demand for finished iron is somewhat quieter, and makers of plates were on Tuesday accepting rather lower prices for favourable specifications. Quotations for ship-plates vary from £4 17s. 6d. to £5 2s. 6d. per ton at makers' works, cash 10th, less 2½ per cent. There is no change in the prices of bars or angles.

Messrs. Bolckow, Vaughan, and Co.'s Eston steelworks will be closed during the Whitsuntide holidays, and probably for a week or ten days longer. Messrs. Fox, Head, and Co.'s Newport Rolling Mills are closed for a fortnight for extensive alterations and repairs. The North-Eastern Steel Works are also to stand for a week or two.

Owing to the continued depression in the Durham coal trade, the Sacriston pit, near Durham, is to be permanently closed; about 150 men will be thrown idle.

Messrs. Palmer's Shipbuilding and Iron Company, of Jarrow, are making preparation to commence the two belted cruisers ordered of them by the British Admiralty. The dimensions of each vessel are as follows:—Length, 300ft.; extreme breadth, 56ft.; displacement, 5000 tons; indicated horse-power, 8500. Some 500 to 600 additional men have been set to work by Messrs. Palmer and Co. during the last three months.

Messrs. Bolckow, Vaughan, and Co. have at last reached the salt through their bore-hole near the Middlesbrough Docks at a depth of 1245ft. At Eston they have sunk 1060ft., but as yet have not been successful.

The fifth and concluding meeting of the Cleveland Institution of Engineers was held at Middlesbrough on Monday evening last. Professor Fleeming Jenkin attended to watch and reply to the discussion of his paper on "Telpher Lines," which had been read at the previous meeting. An interesting and animated discussion took place. It was admitted that such lines could not compete with narrow-gauge tramways where the ground was easy and natural impediments of small account, but they appear to be well adapted to carry a succession of light loads over broken and difficult ground. Two local applications of the system might, it was suggested by members, be advantageously made. The one was to take slag from blast furnaces over intervening railways encumbered with traffic, and deposit it on board craft ready for taking out to sea. The other was to take sacks of flour from Messrs. Appleton's mill, South Stockton, across the river at a high level, and deposit them in trucks at the goods station on the other side. The next paper read and discussed was by Mr. W. Putnam, jun., of Darlington, "On Heavy Forgings." The paper was really a dissertation on the best way to forge and weld stern frames for steamers. It appears that a very large number of failures occur owing to inefficient welding of this important part of a steamship. These failures generally involve breakage of the steering apparatus and often loss of the ship. Some of Lloyd's surveyors were present and took part in the discussion. It appears that there are still many works where such heavy forgings are undertaken without the necessary appliances for dealing with them efficiently.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

THE Glasgow iron market has been very quiet in the past week. Warrants are strongly held, and as the speculative demand is slow, few transactions have taken place. The shipments were comparatively poor, amounting to 9223 tons, as compared with 10,779 in the preceding week, and 9739 in the corresponding week of 1884. Fair exports are being made to Germany and the Australian colonies, but elsewhere the shipments appear to be under the average. There are ninety-two furnaces in blast, as against ninety-five twelve months ago. During the week 950 tons were added to the stock of pig iron in Messrs. Connal and Co.'s Glasgow stores.

Business was done in the warrant market on Friday at 41s. 10d. cash. On Monday the market was inanimate at 41s. 10½d. Tuesday's quotations were 41s. 10½d. to 41s. 11d. cash, and on Wednesday the quotations were 41s. 11d. to 41s. 10d. cash. To-day—Thursday—being a holiday, no market was held.

The demand for makers' iron being slow, the quotations are somewhat easier, as follows:—Gartsherrie, f.o.b. at Glasgow, No. 1, 50s.; No. 3, 46s.; Coltness, 51s. 6d. and 49s. 6d.; Langloan, 51s. 6d. and 49s. 6d.; Summerlee, 49s. 6d. and 45s. 6d.; Calder, 52s. and 45s. 6d.; Carnbroe, 48s. and 45s. 6d.; Clyde, 46s. 9d. and 42s. 6d.; Monkland, 42s. and 40s.; Quarter, 41s. 9d. and 39s. 6d.; Govan, at Broomielaw, 42s. and 40s. 3d.; Shotts, at Leith, 50s. 6d. and 50s.; Carron, at Grangemouth, 52s. 6d. and 47s.; Kinneil, at Bo'ness, 44s. and 43s.; Glengarnock, at Ardrossan, 47s. 6d. and 42s.; Eglinton, 42s. 3d. and 39s. 6d.; Dalmellington, 46s. and 42s.

The placing of a few additional contracts with the Clyde shipbuilders is announced, but there is still much room for improvement in that industry, as may be judged from the fact that about thirty different firms are at present estimating for a cross-channel steamer.

The exports of steel goods from Glasgow include the value of that material—£85,500—used in eleven stern wheel steamers despatched to the Nile by Messrs. Elder and Co., besides £2500 other steel goods despatched to India, Australia, and Canada; £2110 locomotive fittings for Bombay; a tramway engine, value £1600, for Sydney; a steel barge, £8300, for Rangoon; £3800 worth of sewing machines; and iron manufactures to the value of £20,100.

There is a brisk inquiry for coals for shipment at most of the ports, the quantity despatched from Glasgow in the past week being 25,098 tons; Greenock, 836; Ayr, 7562; Troon, 9700; Grangemouth, 16,076; and Irvine, 2190 tons. The inquiry for household sorts is slackening in consequence of the warmer weather now prevalent. In Fife, where the trade had long been backward, there is now more activity at the ports.

An effort is now being made to organise the Lanarkshire miners into an association, with the object of agitating for increased wages and other improved conditions. Those who are directing the movement are meeting with a measure of success; but there are not a few in the ranks of the colliers who remember the hardships that attended former strikes, without any corresponding advantages, and they are inclined to hesitate before committing themselves to an agitation the consequences of which it is impossible to foresee. Frequently the leaders of the miners have been men of poor intelligence, and utterly destitute of the information essential to form a correct view.

The Scotch mineral oil companies are paying very good dividends, with one or two exceptions. Lately the Broxburn directors intimated 25 per cent., and since Clippens has announced 12, Burntisland 20; and Pumpherston has made an excellent return on the work of the first four months of its existence as a going concern. The Burntisland Company have acquired the valuable mineral fields of Grange Estate from Major Ayrton for a period of thirty-one years, and they will soon be in a position to add materially to their output. The Clippens Works are now able to refine from seven to eight million gallons a year, and they have a supply of shale at Pentland of 4000 tons a week. The oilworks of the Linlithgow Company, which were begun about twelve months ago, are now so far completed that operations have been commenced for the manufacture of crude oil. Four benches of Henderson's retorts have been erected, each consisting of fifty-two retorts, and the best possible arrangements have been made for carrying on the manufacture in a successful way. The fall in the values of lubricating oil and sulphate of ammonia has been much against the companies — especially the weak ones—in the past year, but the prospects of the trade appear on the whole to be satisfactory.

WALES & ADJOINING COUNTIES.

(From our own Correspondent.)

A GOOD deal of regret has been expressed at the withdrawal of the Cardiff and Monmouthshire Railway Bill, as this would have developed a new Rhondda amongst the Monmouthshire hills, and made up for the Bute Docks what may be expected to be lost by the Barry. This feeling of regret is not, I must add, shared by the Newport shipowners and others. By them the bill was regarded as most detrimental, and was vigorously opposed. It is now thought that the Rhymney Railway will be brought into requisition to accomplish, by new branches, &c., the object sought for by the Cardiff and Monmouth promoters. Last week's coal export at Cardiff was a very heavy one, though not quite up to the previous, which was one of the heaviest on record—185,000 tons—and this prosperity is fairly shared both at Swansea and Newport, Mon. Last week, for instance, Newport sent away over 40,000 tons of coal to foreign destinations alone, and over 20,000 coastwise. From Newport, Mon., also was sent away 1900 tons of rails for India, and two substantial cargoes to Holmstadt and Soderham. Cardiff sent away only 375 tons of manufactured iron, but amends were made in the case of patent fuel, of which 4539 tons were despatched. In the patent fuel trade both Swansea and Cardiff are well placed, and the market rates are as firm as they have ever been. The ruling price for best brands continues to be 10s.

House coal is in better favour. Prices remain about the same, a trifle stronger perhaps, but the demand is much more active. This was not before it was wanted, for complaints were becoming serious both in the Rhondda and in the Monmouthshire valleys. Small steam is firm and brisk.

Swansea has been doing a fair coal trade with France of late, and last week sent over 3000 tons of patent fuel to the same destination. Its coal trade with Russia is slack, but more pronounced with South America and with Africa.

Pitwood is getting firmer in price, and large sales are taking place at the various ports.

There are some indications that the dark cloud which has overshadowed the iron and steel trade is lifting. Inquiries are on the increase, and more orders are being placed. Canada and India are pretty well represented, and some works are kept going well with the demand for steel from various tin-plate works.

In tin-plate a good business is being done generally, and prices are upon the whole maintained. The best demand at present is for common cokes, odd sizes, and large sheets. Ordinary cokes vary from 13s. 3d. to 14s. Some sales, ordinary brands, have taken place from 13s.

Charcoal sheets of the best sample are sold at 17s. 6d.; terne sheets, 13s. 3d. to 14s. 3d.; wasters as low as 12s. 3d. A temporary stoppage of Llwydarth Tin-plate works, Maesteg, has been resolved upon. This a great blow, as the wages paid monthly amounted to £2000. A promise of a restart in a month has been made if then warranted by trade.

At a meeting of tin-plate representatives, held at Newport this week, it has been decided to support the Rhiwderin men who will be out of work from Saturday next.

THE PATENT JOURNAL.

Condensed from the Journal of the Commissioners of Patents.

*** *It has come to our notice that some applicants of the Patent-office Sales Department, for Patent Specifications, have caused much unnecessary trouble and annoyance, both to themselves and to the Patent-office Officials, by giving the number of the page of* THE ENGINEER *at which the Specification they require is referred to, instead of giving the proper number of the Specification. The mistake has been made by looking at* THE ENGINEER *Index, and giving the numbers there found, which only refer to the pages, in place of turning to those pages and finding the number of the Specification.*

Applications for Letters Patent.

*** When patents have been "communicated," the name and address of the communicating party are printed in italics.

12th May, 1885.

5791. TORPEDO NETS, H. Cheesman and D. B. Morison, Hartlepool.
5792. BUTTON FASTENER, T. W. Taylor, Birmingham.
5793. AUTOMATIC TANK CART, J. Taylor, Haslingden.
5794. REGULATING the BLAST for STEEL CONVERTERS, J. T. King.—(*H. W. Oliver, jun., and J. P. Witherow, U.S.*)
5795. CUTTING or PARING HATS, R. Turner, Hyde.
5796. HYDRAULIC RAMS, F. Ball, Birmingham.
5797. COMBINED LATHE, PLANING, and FLUTING MACHINE, J. Appleyard, Bradford.
5798. RECEPTACLE for PAINTS, &c., G. H. Crowther, Bradford.
5799. LOCK NUT for SCREW BOLTS, W. Harrington, Kidderminster.
5800. LAWN TENNIS, &c., PRESSES, D. B. Morison, Hartlepool.
5801. ELECTRIC BELL PUSHES, &c., C. Brotherhood, Bristol.
5802. PRINTING MACHINES, F. C. Baker, Liverpool.
5803. BOOK-STANDS, J. Walker, Birmingham.
5804. TAKING SOUNDINGS at SEA, J. Robertson, Sunderland.
5805. RANGE FINDING and MEASURING ANGLES, J. H. Steward, London.
5806. TOASTING FORKS, H. Tibbins, Birmingham.
5807. COMBINING a MUSIC-STAND and UMBRELLA in ONE, R. Black, Aberdeen.
5808. GRAPNELS, H. C. Mance, Brockley.
5809. ATTACHING, &c., FLIES to FISHING LINES, J. Peek, London.
5810. STOPPING, &c., TRAM-CARS, S. Sheppard, H. G. Barnes, and J. A. O'Connell, Dublin.
5811. STEAM GENERATORS, W. Clarke, London.
5812. WIRE FENCING, P. S. Brown, Glasgow.
5813. DIFFERENTIAL HOISTING MACHINERY, J. Christie and P. Roberts, London.
5814. BOILERS, E. Kemp, Glasgow.
5815. BOOK-SEWING MACHINES, E. and E. Cheshire, London.
5816. PREVENTION of the FORMATION of BOILER CRUST, F. J. Austin and S. Low, jun., London.
5817. STEP for VELOCIPEDES, F. W. Hare, Birmingham.
5818. FEEDING CARDING, &c., MACHINES, H. J. H. King, Newmarket.—*9th May*, 1885.
5819. METALLIC LASTS, A. J. Boult.—(*G. A. Reynolds, U.S.*)
5820. SECURING RUBBER BANDS to WHEELS, A. L. Caporn, London.
5821. SIGNALLING APPARATUS, A. J. Boult.—(*A. Montenegro, Spain.*)
5822. FASTENINGS for SURGICAL BELTS, &c., E. M. Moore, London.
5823. TYPE-BARS, &c., A. J. Boult.—(*O. Mergenthaler, U.S.*)
5824. FORGING and TEMPERING INGOTS, W. Hainsworth, London.
5825. CIGARETTES, S. Pitt.—(*A. W. Jadovsky, Russia.*)
5826. CLOSING the FRONTS of GARMENTS, A. Slazenger-Moss, London.
5827. TRICYCLES, H. Baines, Glasgow.
5828. VULCANISING the INSULATING COVERING of ELECTRICAL CONDUCTORS, B. J. B. Mills.—(*J. J. C. Smith, United States.*)
5829. EXPLOSIVE COMPOUND, J. G. Byrne and S. H. Emmens, London.
5830. BLUEING IMPLEMENT, J. Wright.—(*G. B. Miller, United States.*)
5831. RAZORS, J. C. Mewburn.—(*A. Bain, France.*)
5832. DISINFECTING WATER-CLOSETS, H. J. Haddan.—(*W. M. Ernst, United States.*)
5833. DRAUGHT EQUALISERS, H. J. Haddan.—(*J. W. Wainwright, United States.*)
5834. KNIFE and FORK CLEANERS, C. Ulrig, London.
5835. LOOMS, A. C. Henderson.—(*T. Klaus, France.*)
5836. NEEDLES for BRUSHES, W. R. Lake.—(*J. M. Pickering, United States.*)
5837. GAUGING OUT BRISTLES, W. R. Lake.—(*J. M. Pickering, United States.*)
5838. VALVE COCK, G. Symes, London.
5839. SETTING BUTTONS, W. R. Lake.—(*A. M. English, United States.*)
5840. HOISTING MACHINERY, W. R. Lake.—(*J. J. White and H. White, United States.*)
5841. TAPS or VALVES, A. Gilchrist, jun., Glasgow.
5842. STETHOSCOPES, R. J. Hutton, London.
5843. CURLING, &c., HAIR, W. Bown and G. Capewell, London.
5844. DELIVERY APPARATUS for WEB PRINTING MACHINES, W. Conquest.—(*R. Hoe and Co., U.S.*)
5845. CUTTING PRINTED WEBS of PAPER into SHEETS, &c., W. Conquest.—(*R. Hoe and Co., U.S.*)
5846. FOLDING and DELIVERY MECHANISM, W. Conquest.—(*R. Hoe and Co., U.S.*)
5847. ADJUSTABLE PENDANT for ELECTRIC LAMPS, A. E. Jones, London.
5848. INDICATING FLOW of WATER, &c., through PIPES, J. H. Pickford, Manchester.
5849. EXTINGUISHING FIRES, J. H. Pickford, Manchester.
5850. METAL WATER-TANKS for GASOMETERS, O. Intze, London.
5851. ELEVATED RAILWAY and other HIGH-LEVEL TANKS, O. Intze, London.
5852. AUTOMATIC RAILWAY WAGON COUPLING, H. Beaumont, London.
5853. SIZE for PAPER MAKING, F. Maxwell-Lyte, London.
5854. HELIOGRAPHIC SIGNALLING by ELECTRICITY, E. S. Bruce, London.
5855. SAWING OFF and BORING WHEEL FELLIES, A. M. Clark.—(*W. H. Stevens, U.S.*)
5856. REFRIGERATING APPARATUS for RAILWAY FREIGHT CARS, A. M. Clark.—(*D. Hennessy, U.S.*)
5857. SUPPORTING HOP POLES, E. R. Salwey, London.
5858. RAILWAY CARRIAGE AXLES, A. M. Clark.—(*J. Bourne, jun., U.S.*)
5859. PIANOFORTES, J. Brinsmead, London.
5860. PERMANENT WAY of RAILWAYS, A. M. Clark.—(*M. A. Glynn, Cuba.*)
5861. PRODUCING COMBINED FIBROUS and like THREADS, A. Wilkinson, London.
5862. PENCIL or PEN CASES, &c., B. Willcox, London.
5863. TYPE WRITER, J. D. F. Andrews, London.
5864. ASBESTOS MICROMEMBRANES, O. Imray.—(*F. Breyer, Austria.*)
5865. PROPELLING STEAMSHIPS, C. F. Haider, London.
5866. TOOL for CUTTING WOODEN PINS, &c., C. R. Blathwayt, London.
5867. TORPEDOES, J. G. H. Hill, London.

13th May, 1885.

5868. GAS PLIERS and PIPE CUTTER, A. H. Davies and J. M. Langley, Nottingham.
5869. SPRING MATTRESSES, W. Gadd, Manchester.
5870. CHIMNEY TOPS, H. Sutcliffe, London.
5871. ALARM GUNS, H. Perrins and H. E. Pollard, Worcester.
5872. VELOCIPEDES, W. Parnall, Bristol.
5873. MEASURING WATER, &c., C. S. Bilham, Norwich.
5874. SECURING the FALLING of the WIRES in HORROCK'S PATENT FOLDING FRAME, C. Holdsworth, T. Barnes, and J. Hardy, Halifax.
5875. TORPEDOES, J. Whitley, Leeds.
5876. STRIKING CHINESE GONGS, E. Cox-Walker, Darlington.
5877. CARDING ENGINES, J. Elce and T. S. Whitworth, Manchester.
5878. DRAWING CORKS, J. H. Smiles, Stockton-on-Tees.
5879. ELECTRIC LAMPS, &c., W. P. Thompson.—(*T. Elcoate, Egypt.*)
5880. FILTERS, W. Oldham, Manchester.
5881. INCREASING the EFFECTIVE POWER of MAN or ANIMALS in PROPELLING BOATS, &c., D. Cockshaw, Glass Houghton, near Normanton.
5882. POTASSIUM SULPHITES, A. Boake and F. G. A. Roberts, London.
5883. BREWING, A. Boake and F. G. A. Roberts, London.
5884. DRY GAS METERS, G. Glover and S. Grey, Westminster.
5885. VELOCIPEDES, G. A. Wright and J. de L. Watson, London.
5886. MILK OIL, A. Haacke, London.
5887. AUTOMATICALLY REPLENISHING AIR VESSELS, G. F. Deacon, Liverpool.
5888. TUBULAR STEAM BOILERS, R. H. Taunton, London.
5889. AIR-TIGHT RECEPTACLES, J. T. Richardson, Hampstead.
5890. RAILWAY CARRIAGE LAMPS, I. Blake and Major Dain, London.
5891. SIFTING MACHINES, H. J. Haddan.—(*Escher, Wyss, and Co., Germany.*)
5892. SPEED-CHANGING MECHANISM, B. B. Powell, Columbia.
5893. DRILLS, &c., S. P. Graham, J. L. Blain, and J. P. Cook, Canada.
5894. TAKING-UP MOTIONS, J. Cowburn and C. Peck, Manchester.
5895. PHOTOGRAPHIC CAMERAS, &c., G. P. Smith, Tunbridge Wells.
5896. GAS BURNERS, J. Lewis, London.
5897. STRETCHING LAWN TENNIS NETS, A. Y. Bingham, London.
5898. IMPROVEMENT APPLIED to the GAME of BILLIARDS, W. Pope, London.
5899. POSTS of STREET LAMPS G. A. Skinner, London.
5900. FUEL ECONOMISER, &c., J. B. Hodgson, London.
5901. PRINTING PRESSES, C. Campbell, Glasgow.
5902. INDIA-RUBBER SOLES for BOOTS and SHOES, F. Buckingham, London.
5903. FILTER PRESSES, O. Imray.—(*H. B. Scott, France.*)
5904. CLEANING KNIVES and FORKS, G. A. Skinner, London.
5905. FUNNELS, W. Heatley and G. Hutchens, London.
5906. RAILWAY SIGNALLING APPARATUS, J. Tomlinson and A. Chambers, London.
5907. SAFETY MECHANISM for the SALE of RAILWAY TICKETS, J. Amsler-Laffon, London.
5908. CIGARS, T. Bear, London.
5909. COPPER-PLATE and RELIEF ENGRAVING, E. de Pass.—(*A. S. J. Miron, France.*)
5910. WATERING-POT, J. Haws, Clapton.
5911. PORTABLE TABLET or TRAY, W. Stobbs, London.

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5912. TURNING LATHES, &c., A. G. Meeze, Redhill.
5913. FIXING and SECURING DOOR KNOBS, &c., H. F. Waldron, Sheffield.
5914. IRONING and SMOOTHING BOOT and SHOE UPPERS, &c., J. H. Iliffe, Leicester.
5915. FISHING-ROD JOINTS, T. Kirker and A. Hunter, Belfast.
5916. WINDOW-SASH FASTENER, J. Quarmby, Manchester.
5917. OILCAN, J. Quarmby, Manchester.
5918. LUBRICATOR, J. Quarmby, Manchester.
5919. NITRATE of AMMONIA, &c., J. F. Chance, Liverpool.
5920. ALKALINE LEES, J. F. Chance, Liverpool.
5921. KEYING APPARATUS for RAILWAY CHAIRS, W. P. Thompson.—(*G. F. Horbury, East India.*)
5922. BOTTLING AERATED WATERS, W. Fairhurst, Liverpool.
5923. GROOVING the SURFACES of ROLLERS, G. F. Thompson, Liverpool.
5924. SAFETY CENTRE PINION APPLICABLE to GOING BARREL WATCHES, C. Mackenzie, Liverpool.
5925. HAT CASES, &c., H. Heath and W. T. Smith, London.
5926. THUMB LATCHES, J. Large, Birmingham.
5927. MILITARY SADDLE, H. S. Wilton and B. S. Weston, London.
5928. RAILWAY CONSTRUCTION, T. H. Gibbon, Sheffield.
5929. DECORATING GLASS, &c., L. Winterhoff, London.
5930. METALLIC LEAD, W. E. Gedge.—(*S. Trayner, Spain.*)
5931. ATTACHING LIDS to DESKS, &c., G. M. and E. J. Hammer, London.
5932. BASTING MEAT, T. S. Archer, London.
5933. SUSPENDING STOCKINGS, M. Wilson, London.
5934. VALVE-GEAR, F. Bosshardt.—(*J. R. Frikart, France.*)
5935. INCREASING SPEED of VESSELS, S. A. Johnson, London.
5936. LETTING-OFF MOTIONS in LOOMS, J. Pinder, London.
5937. FASTENING STOPPERS in JARS, &c., J. B. O'Callaghan, London.
5938. PHOTOGRAPHIC CAMERAS, S. W. Rouch, London.
5939. DANDY ROLL, C. W. J. L. de Robert, London.
5940. BOILERS, &c., for TREATING FIBROUS MATERIALS, A. J. Boult.—(*E. Vossnack, Canada.*)
5941. RIBBED FABRIC, S. Davis, F. Moore, and J. T. Coltman, London.
5942. MODERATOR LAMPS, A. C. Henderson.—(*Messrs. Bourdon, Jaquemin, and Gremiom, France.*)
5943. PEN-WIPER for COAT-SLEEVES, W. Timms, Darlington.
5944. SIGNALLING by ELECTRICITY, E. B. Bright, London.
5945. OBTAINING AMMONIA, &c., COMPOUNDS, A. French, Glasgow.
5946. SAFETY VALVES, W. H. Northcott, London.
5947. DRYING APPARATUS, A. Munzinger, London.
5948. FURNACES, &c., J. S. Stallard.—(*W. H. Richardson, United States.*)
5949. STEAM CONDENSING ENGINES, H. Edwards, London.
5950. DECORATING ARTICLES of EARTHENWARE, S. Lear, London.
5951. MECHANICAL MUSICAL INSTRUMENTS, H. J. Haddan.—(*G. Richter, Saxony.*)
5952. OIL LAMPS and LANTERNS, H. J. Haddan.—(*L. Sepulchre, Belgium.*)
5953. PROJECTILES, T. Stead.—(*D. Moore, United States.*)
5954. STEAM ENGINES, A. Reis, London.
5955. ARTIFICIAL FUEL, F. Snelling, London.
5956. GLAZING BARS for ROOFS, WINDOWS, &c., W. Lester, Glasgow.
5957. PERFORATING HOLES for WIRE HINGES, J. H. Young, Glasgow.
5958. IMPLEMENT to SPLIT and SAW WOOD, &c., F. Grüring-Dutoit, London.
5959. ARGAND GAS BURNERS, J. Lewis, London.
5960. COMPOSITE PROJECTILE for SMALL-ARMS, &c., R. Morris, London.
5961. APPLYING CHENILLE to BOBBIN-NET LACE, &c., E. Lion, London.
5962. SPRING BUTTON APPLIANCE, H. Gardner.—(*W. Ullrich, Germany.*)
5963. RING SPINNING and DOUBLING FRAMES, W. L. Wise.—(*E. Hofmann, Germany.*)

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5964. BEDDING and POTTING BARROW, H. Swete, Worcester.
5965. PHOTOGRAPHIC CAMERA, E. and T. A. Underwood, Birmingham.
5966. PROPELLING TRICYCLES, BOATS, &c., J. H. Poole, Glasgow.

5967. HORSE COLLARS, R. Larkin, Rye.
5968. FACILITATING the MOVEMENT of LOCOMOTIVES, &c., J. Batley, London.
5969. FORCING SYRUPS, &c., into BOTTLES, W. Bratby and J. Chadwick, Manchester.
5970. STUFFING-BOXES, J. G. Kinghorn and A. Horne, Liverpool.
5971. GAS MOTOR ENGINES, E. C. Mills, Northwold.
5972. LOCK MECHANISM for REVOLVERS, G. Envall, London.
5973. METALLIC ANTIMONY, C. H. McEuen, London.
5974. ROLLING STRENGTHENING RINGS on CIRCULAR FLUES, &c., D. Purves, North Dulwich.
5975. REEFING BANDS for MANTLES, &c., W. Herbert, Torquay.
5976. CONSTRUCTING PIPES, TUBES, &c., T. Monks, Liverpool.
5977. RENDERING COPPER PRINTING PLATES MORE DURABLE, H. Minton-Senhouse.—(*H. Capelle, Paris.*)
5978. CLIPS or HOLDERS for PAPERS, &c., J. Wheeler, London.
5979. BRAKES for CARRIAGES, &c., J. A. McNaught, Worcester.
5980. GAS PRODUCERS, A. Wilson, London.
5981. MEASURING and INDICATING the VELOCITY and FORCE of CURRENTS of AIR and GASES, J. A. Muller, London.
5982. ASBESTOS PACKED COCKS, J. Dewrance and G. H. Wall, London.
5983. SEWING MACHINES, H. J. Haddan.—(*A. Wedermann, Austria.*)
5984. WALKING STICKS and UMBRELLA HANDLES, J. Knight, London.
5985. CARRIAGE DOOR FURNITURE, &c., C. D. Douglas, London.
5986. PRINTING MACHINERY, J. M. Black, London.
5987. COMPOSITION for CLEANING FIRE-GRATES, &c., A. Holmes, London.
5988. RAIL FASTENINGS and JOINTS, J. Poyser, London.
5989. MOUNTING FLAT TANG CAVALRY SWORDS, F. M. Mole, London.
5990. TELEGRAPH POLES, COLUMNS, &c., D. Wilson, London.
5991. QUANTITATIVE ESTIMATION of HÆMOGLOBIN in the BLOOD, A. M. Clark.—(*E. F. von Marxow, Austria.*)
5992. BUNDLE CARRIERS for SHEAF BINDER HARVESTING MACHINES, W. McI. Cranston.—(*W. A. Wood, United States.*)
5993. WATERPROOF COVERING for ROOFS, &c., A. Ford and J. A. Archer, London.
5994. STEAMERS, J. G. Webb, London.
5995. SCREENING and CLASSIFYING MINERALS, W. Fairweather.—(*J. Karlik, Austria.*)
5996. TREATING ALUMINOUS IRON ORES, &c., T. Jack, jun., Glasgow.
5997. STEEL, L. A. Groth.—(*R. Weckbecker, Luxemburg.*) —23rd April, 1885.
5998. SOAP PASTE for CLEANSING WOOL, M. S. Gosling, Moseley.
5999. PHOTOGRAPHIC APPARATUS, B. J. B. Mills.—(*F. Denis, France.*)
6000. REMOVING MUD from STREET GULLIES, E. Burton, London.
6001. ROAD PAVING, W. Jameson, London.
6002. STOPPERING BOTTLES CONTAINING AERATED LIQUIDS, J. Wilkinson, London.
6003. ROCK DRILLS, O. Imray.—(*B. A. Legg, U.S.*)
6004. GLOVE FASTENERS, I. Wilkinson, London.
6005. SELF-ACTING ENGINE, &c., C. E. D. F. de Livet, London.
6006. COMPOUND STEAM ENGINES, W. Brock, Glasgow.
6007. LAWN MOWERS, J. Hopwood, London.

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6008. TREATING WATERPROOF FABRICS, I. Frankenburg, Manchester.
6009. INSTANTANEOUSLY HEATING WATER, &c., W. J. Righton, London.
6010. HEATING WATER by CIRCULATION, W. J. Righton, London.
6011. INDIA-RUBBER TIRES, C. Moseley and B. Blundstone, Manchester.
6012. GIRDERS, R. A. Stoffert and T. Dykes, Glasgow.
6013. HEATING APPARATUS, W. E. Heys.—(*J. F. Hauser, Germany.*)
6014. ROTARY ENGINES, T. Marshall, Glasgow.
6015. PROPELLING and STEERING SUBMARINE BOATS, &c., H. D. Child, Twickenham.
6016. DRIVING BANDS or CHAINS for TRICYCLES, &c., E. C. Clarke, Derby.
6017. RAISING, &c., LAMP GALLERIES, G. R. Lewis, Birmingham.
6018. PREPARING WASTE for BLEACHING PURPOSES, T. J. Hutchinson, Bury.
6019. CLEANING BOOTS and SHOES, T. Bradford, Manchester.
6020. PREPARING WOOD WOOL, W. E. Heys.—(*H. A. Gütschow, Germany.*)
6021. SHIELDS for GUNS, C. Brown and W. F. Bayliss, Birmingham.
6022. WOVEN DRIVING BANDS or BELTS, I. Jackson, Manchester.
6023. WATCH POCKET, J. R. Frier, Derby.
6024. HANDLES for SPOONS, &c., F. Crockford, Sydenham, and C. Hickson, Sheffield.
6025. FIRE-RESISTING CEMENT, W. Montgomery, London.
6026. PICKING MECHANISM for OVER-PICKED LOOMS, J. Boyd, Glasgow.
6027. FIRE-PROOF BUILDINGS, J. and T. Tulloch, Glasgow.
6028. LOCOMOTIVE and other STEAM ENGINES, F. B. Doering, London.
6029. FIRE-ARMS, J. D. Lucas and W. J. Kriz, London.
6030. DRAWING or SKETCHING, C. M. Linley, J. Biggs, and G. G. Tandy, London.
6031. REFINING SUGAR, J. Duncan and B. E. R. Newlands, London.
6032. MOULDS, J. Duncan and B. E. R. Newlands, London.
6033. NEEDLES, &c., G. E. Smart, Tunbridge Wells.
6034. VENTILATORS, R. W. Hale, London.
6035. WORKING the STEAM VALVES of NON-ROTATIVE PUMPING ENGINES, H. W. Pendred, Crohill.
6036. PURIFYING AIR and PROMOTING VENTILATION, A. Bell, London.
6037. ELECTRO-MOTORS and DYNAMO MACHINES, M. Immisch, London.
6038. REGULATING the SPEED of ELECTRO-MOTORS, M. Immisch, London.
6039. BLASTING and SHOT FIRING in MINES, J. Heath and W. Frost, London.
6040. CARTRIDGES, J. O. Byrne and S. H. Emmens, London.
6041. SUSPENDING LAMPS, A. C. Henderson.—(*P. E. Jullien, France.*)
6042. GENERATING ELECTRIC CURRENTS, R. H. Courtenay, London.
6043. COMPOUND DONKEY ENGINE, PUMP, and CONDENSER, J. Kirkaldy, London.
6044. PROTECTING the CONTENTS of WATER BOTTLES, S. W. Silver, London.
6045. ARTIFICIAL SILK-LIKE FILAMENTS, C. D. Abel.—(*H. Chardonnet, France.*)
6046. SPRING WHEELS for TRACTION ENGINES, J. H. Mann, London.
6047. OBTAINING MOTIVE POWER, A. Rigg, London.
6048. TREATING CARBONACEOUS, &c., SUBSTANCES, H. Aitken, London.
6049. COFFEE EXTRACT, D. Ker, London.
6050. COCOA PASTE, D. Ker, London.
6051. TEA EXTRACT, D. Ker, London.
6052. BOILER FILLER and TOILET and WATERING CAN COMBINED, H. Inglis and G. H. Laxton, London.
6053. FURNACES for the COMBUSTION of REFUSE, E. Burton, London.
6054. SEWAGE PURIFICATION PROCESSES, F. Maxwell-Lyte, London.
6055. TREATING SEWAGE, W. B. G. Bennett, London.
6056. DISENGAGING APPARATUS for SHIPS' BOATS, C. Hodge, Glasgow.
6057. CALICO-PRINTING MACHINES, &c., W. Stewart Glasgow.
6058. SEWING MACHINES, A. Anderson and R. A. F. Pollock, Glasgow.
6059. FURNACES of RETORT CHAMBERS, J. McNair, Glasgow.
6060. GRAIN BOLTING, &c., MACHINE, G. F. Redfern.—(*L. Pinet, France.*)
6061. BELTING, &c., for RAILWAY CARRIAGE WINDOWS, G. F. Redfern.—(*G. Rittig, Sweden.*)

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6062. HEELS of BOOTS, R. A. F. A. Coyne, Edinburgh.
6063. PRESSING STANDS, C. H. and F. J. Dale, Leicester.
6064. DRAWING COMPASSES, F. Harris, Birmingham.
6065. CONCENTRATING AQUEOUS SOLUTIONS, W. P. Thompson.—(*A. Büttner and C. Meyer, Germany.*)
6066. COOLING GASES and VAPOURS, W. Weldon.—(*A. R. Pechiney et Compagnie, France.*)
6067. ELECTRIC DRILLING MACHINES, S. A. Houghton, Devonport.
6068. MECHANICAL GAME or PASTIME, W. Stobbs and E. L. White, London.
6069. IGNITING COMBUSTIBLE CHARGES, W. Muir, London, and D. C. Smith, Bath.
6070. SOUNDING INSTRUMENTS, Cooper and Wigzell, London.
6071. COLLAPSIBLE WARDROBE, H. J. Haddan.—(*R. Hoeborn and H. Bünte, Germany.*)
6072. PERPENDICULAR SIEVE, A. Swonnell, Brixton.
6073. METALLIC BEDSTEADS, G. A. Barth and W. Ramsey, London.
6074. COMPOSITION for WASHING DOGS, W. H. Scratton, London.
6075. HARDENING or TEMPERING SHEET STEEL, J. B. Jackson, London.
6076. STEREOSCOPE, R. Rayner, London.
6077. SANITARY and other PIPE JOINTS, G. H. Thynne, London.
6078. SELF-APPLYING EXCENTRIC GRIPPING APPARATUS, J. Langdon, Hull, J. A. Wade, and J. Cherry, Hornsea.
6079. STRETCHER for TROUSERS, J. M. B. Baker, London.
6080. SECURING BOXES, &c., to STANDS, E. Buck, London.
6081. LADIES' HEAD DRESSES, F. L. Smith, London.
6082. PRIMARY DRY GALVANIC BATTERY CELL, F. Walker and C. Smith, London.
6083. HAIR COMBS, J. Hargreaves, London.
6084. EXPLOSIVE PROJECTILES, H. R. Lake.—(*B. Fannon and C. P. Winslow, U.S.*)
6085. PROTECTION of WOOD from MOISTURE, H. H. Lake.—(*J. Leiter Austria.*)
6086. ROTARY BRUSHES, F. Richardson, London.
6087. PIANOS, C. Hampton, London.
6088. GALVANIC BATTERIES, E. B. Burr, London.

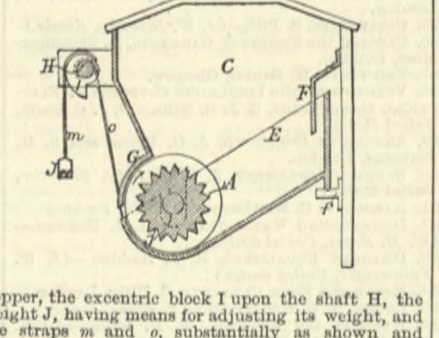
SELECTED AMERICAN PATENTS.

(From the United States' Patent Office Official Gazette.)

314,627. FEED REGULATOR FOR ROLLER MILLS, *Forrester M. Tallow, Hannibal, Mo.—Filed May 20th, 1884.*

Claim.—(1) The combination, with the hopper C, having an adjustable bottom, of the shaft H, carrying the excentric block I, the weight J, the connections *o m*, and the longitudinally grooved roller A, journalled in the sides of the hopper, substantially as shown and described. (2) The combination, with the hopper C and the roller A, journalled therein, of the hinged shoe E, the excentric block I, the straps *m o*, the weight J, and the cant board F, substantially as herein shown and described. (3) The combination, with the hopper C, shoe E, and longitudinally grooved roller A, of the shaft H, journalled at the front side of said

314,627

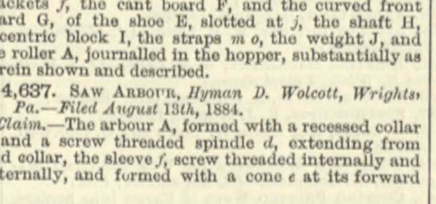


hopper, the excentric block I upon the shaft H, the weight J, having means for adjusting its weight, and the straps *m* and *o*, substantially as shown and described, and for the purpose set forth. (4) The combination, with the hopper C, provided with the brackets *f*, the cant board F, and the curved front board G, of the shoe E, slotted at *j*, the shaft H, excentric block I, the straps *m o*, the weight J, and the roller A, journalled in the hopper, substantially as herein shown and described.

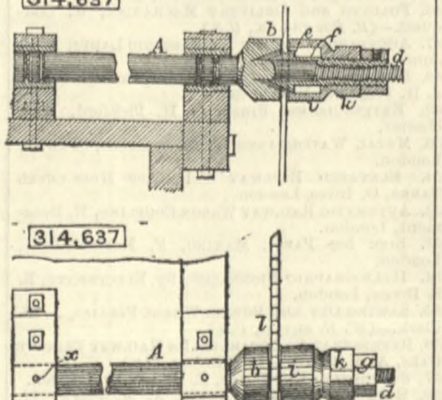
314,637. SAW ARBOUR, *Hyman D. Wolcott, Wrightsr Pa.—Filed August 13th, 1884.*

Claim.—The arbour A, formed with a recessed collar *b*, and a screw threaded spindle *d*, extending from said collar, the sleeve *f*, screw threaded internally and externally, and formed with a cone *e* at its forward

314,637



314,637

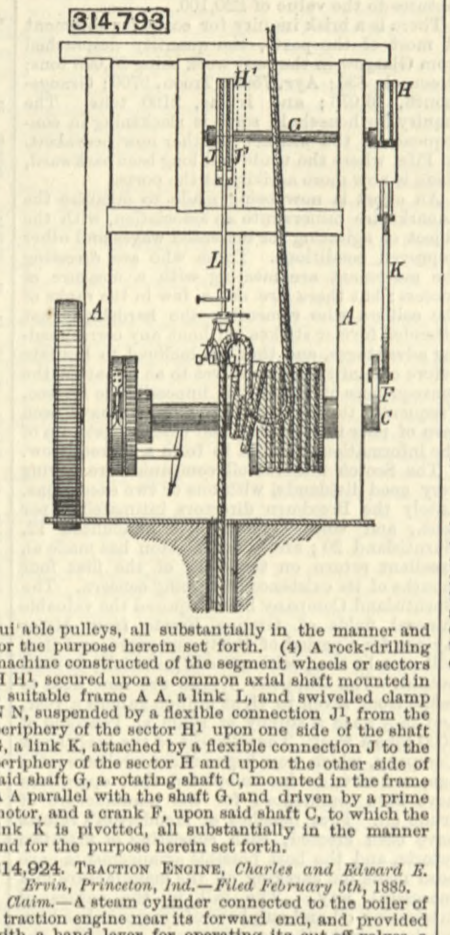


end, the recessed collar *i*, extending over cone *e* and formed with a nut *k*, fitting on the exterior of sleeve *f*, and the nut *g* on the outer end of sleeve *f*, substantially as set forth.

314,793. ROCK-DRILLING MACHINE FOR ARTESIAN WELLS, *J. Button, New York, N.Y.—Filed July 25th, 1884.*

Claim.—The combination, in a rock-drilling machine, with an oscillating segmental pulley secured to a rock shaft in line with the drill rope and its suspension pulley, and adapted to be reversed to clear the rope and permit a withdrawal thereof of the drill tool, of one or more flexible bands or cords led over and secured to the periphery of the segmental pulley and adapted for attachment to the drill rope, for the purpose of lifting and dropping the drill tool by the movement of the rock shaft, substantially in the manner and for the purpose herein set forth. (2) In a rock-drilling machine, the combination, with an oscillating segmental pulley fixed upon a rock shaft actuated by a prime motor, of a swivel suspended from one or more cords or bands led over and secured to the periphery of said segmental pulley, and a device for attaching the drill rope to the swivel, substantially in the manner and for the purpose herein set forth. (3) The combination, in a rock-drilling machine, with a rope carrying the drill tool, of a cord or cords suspended from the periphery of a segmental pulley and adapted for attachment to the drill rope, a rock shaft to which the pulley is secured, a driving shaft geared to said rock shaft to produce its oscillation, and an independent drum or shaft adapted to be thrown into gear with the driving shaft by a clutch, and to wind by its rotation the drill rope led thereto over

314,793

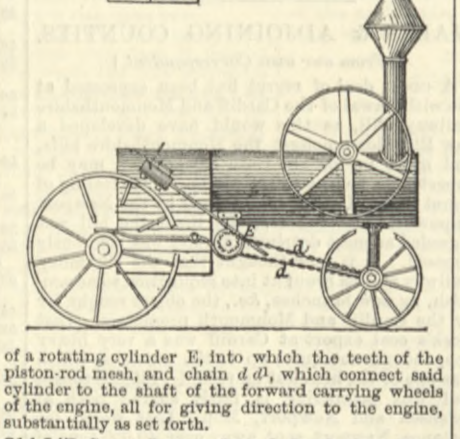


suitable pulleys, all substantially in the manner and for the purpose herein set forth. (4) A rock-drilling machine constructed of the segment wheels or sectors H H[1], secured upon a common axial shaft mounted in a suitable frame A A, a link L, and swivelled clamp N N, suspended by a flexible connection J[1], from the periphery of the sector H[1] upon one side of the shaft G, a link K, attached by a flexible connection J to the periphery of the sector H and upon the other side of said shaft G, a rotating shaft C, mounted in the frame A A parallel with the shaft G, and driven by a prime motor, and a crank F, upon said shaft C, to which the link K is pivotted, all substantially in the manner and for the purpose herein set forth.

314,924. TRACTION ENGINE, *Charles and Edward E. Ervin, Princeton, Ind.—Filed February 5th, 1885.*

Claim.—A steam cylinder connected to the boiler of a traction engine near its forward end, and provided with a hand lever for operating its cut-off valves, a piston-rod with gear teeth, a gear wheel upon the end

314,924

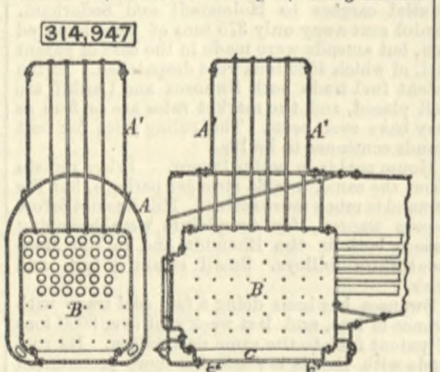


of a rotating cylinder E, into which the teeth of the piston-rod mesh, and chain *d d*[1], which connect said cylinder to the shaft of the forward carrying wheels of the engine, all for giving direction to the engine, substantially as set forth.

314,947. STEAM BOILER, *Peter I. Lynch, Corry, Pa.—Filed April 17th, 1884.*

Claim.—In a steam boiler, the combination, with the plates A and B, of the water ring C, having internal

314,947

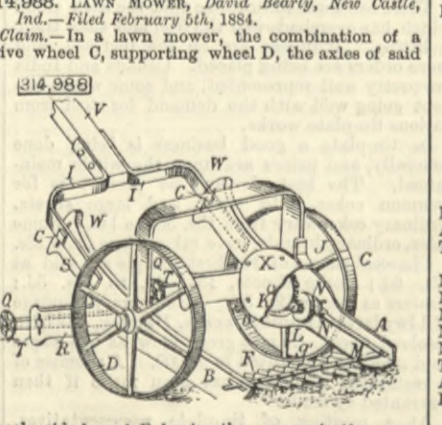


flange *c*[1], and external flange *c*[2], substantially as shown.

314,988. LAWN MOWER, *David Bearly, New Castle, Ind.—Filed February 5th, 1884.*

Claim.—In a lawn mower, the combination of a drive wheel C, supporting wheel D, the axles of said

314,988



wheels, side bars A B, having the rear projecting arms R S, provided with the curved slots, connecting yoke E, adjustable arms T[1], adjustable handle braces I, fixed cutter bar *g*, provided with reversible knives *g*[1], reversible reciprocating cutter-bar F, gear wheel K on the axle of the drive wheel shaft O[2], pinion O, and cam wheel L, fixed to said shaft, the boss *y* on the side plate A, lever M, provided with aperture N, passing over said boss and pivotted to the boss, and also provided with friction rollers N[1] N[2], adapted to engage the cams on said wheel L, and with a slot at its forward end for receiving the cutter-bar F, to which it is pivotted, the shield X, and the removable rim of the plate A, substantially as and for the purposes set forth.

314,995. COVERING FOR CABLES OR ROPES USED TO PROPEL VEHICLES, *Chester Bullock, New York, N.Y. —Filed July 7th, 1884.*

Brief.—Loose rings are held in place upon the cable between clutch rings, which consist of threaded and slotted sections screwed into outer sections having

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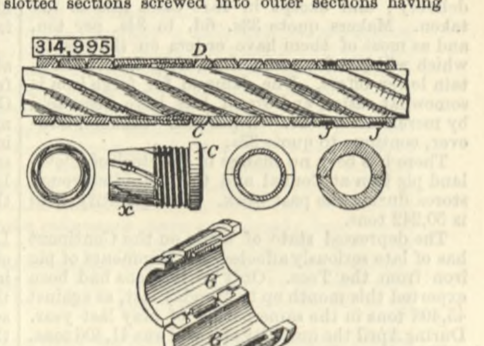
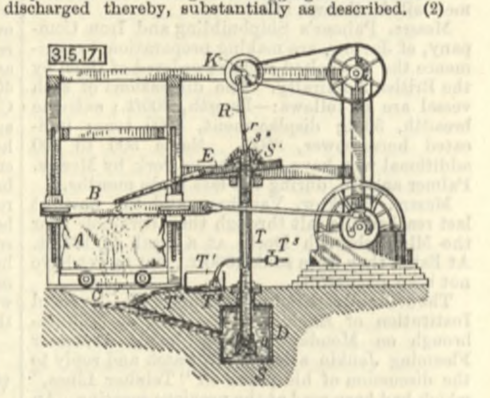


inclined inner surfaces which force the slotted portions against the cable. Sectional rings divided longitudinally are secured to cable by wire wrapped around them where splices occur.

315,171. SAND AND WATER FEED MECHANISM FOR STONE SAWING MACHINES, *W. L. Saunders, Jersey City, N.J.—Filed November 17th, 1884.*

Claim.—(1) In a stone cutting machine, the combination, with a stone saw and mechanism for operating the same, of a hopper and discharge way adapted to collect and convey the sand and water running from the stone, an automatically-operated reciprocating pump for elevating the collected sand and water, a trough leading from the pump to the saw, and a distributing device carried by the pump and adapted to prevent the settling and clogging of the material discharged thereby, substantially as described. (2)

315,171



In a stone sawing machine, the combination of a sand and water discharge way and collecting tank, a reciprocating tube provided at its lower end with an upwardly-opening foot valve located within said tank, whereby the contents thereof are continually agitated, and at its upper end with a discharge surface, whereby the mixture is prevented from settling and clogging, a suitable conduit for receiving and conveying the mixture to the stone, and mechanical connections, substantially as described, for imparting motion to the tube.

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