TABLE II. ELLIPTIC STERN OF VESSELS.

Exponent.	ORDINATES FOR ELLIPSES OF DIFFERENT ORDER.							
n	½	1	2	3	4	5	6	7
2	·3398	·4840	·6616	·7808	·8660	·9204	·9682	·9922
2¼	·4108	·5490	·7147	·8274	·9004	·9495	·9801	·9958
2½	·4670	·5537	·7057	·8627	·9252	·9646	·9873	·9978
2¾	·5174	·6514	·8029	·8901	·9434	·9749	·9932	·9989
3	·5604	·6911	·8331	·9019	·9565	·9821	·9948	·9994
3¼	·5991	·7252	·8578	·9275	·9664	·9871	·9973	·9996
3½	·6333	·7548	·8782	·9406	·9740	·9907	·9978	·9998
4	·6906	·8021	·9093	·9595	·9840	·9950	·9995	·9999
Sheer	30°	·0149	·0582	·1321	·2374	·3740	·5449	·7531
of	45°	·0157	·0539	·1221	·2152	·3517	·5227	·7313
Vessels.	60°	·0160	·0474	·1086	·1972	·3190	·4794	·6946

SHEER.—The sheer lines are calculated for circle-arcs of 30°, 45°, and 60°; they will be ellipses of the second order; for 30° the elliptical form is hardly perceptible, but for 60° it is more so.

DEAD FLAT.—There is a difference of opinion among shipbuilders as to where to place the dead flat Q. Some place it forward, some abaft, and some in the middle of the vessel. It appears that on sailing vessels the dead flat should be located forward, on account of the centre of effort of the sails being high above the ship. In paddle steamers the dead flat should be located in the centre, and in propellers abaft the centre. In sailing yachts the dead flat is most generally abaft the centre.

The yacht *America*, which won the prize at the Exhibition in London in 1851, had her dead flat about three-eighths from the stern. The yacht *America* is a perfect model of the parabolic construction; her exponents are $n = n' = 2$, and $n'' = 2\frac{1}{4}$, with no hollow lines.

The clipper ship *Great Republic* had her dead flat abaft the centre, and the centre of effort of her sails was about 12ft. ahead of the centre of gravity of her displacement. This is an exceptional case; in sailing vessels the dead flat is most generally placed forward of the centre.

HOLLOW LINES.—It is the fashion in our days to make the load water-line hollow fore and aft. which fancy is only pleasing and deceiving to the eye. Experiments have been made with a view to find out some less resistance to vessels with hollow lines, but have not, that I am aware of, given any satisfactory results. The hollow lines take away a good portion of the displacement, and diminish the strength and stability of the vessel. In order to follow up the fashion I will here describe how hollow lines are formed in the parabolic construction. Let i, Fig. 1, be the point where the hollow line is to commence; draw through i a line parallel to the centre line, draw the ordinate z, find $z' = z$, make $a = a'$; then e is the stem or stern of the boat. Draw equal number of ordinates on a and a', by which the line $e'\,i$ is transferred to $i\,e$, and forms the hollow part of the water-line. The ordinate z is the measure of the hollow line, and ought not to exceed $z = \frac{1}{4}\,b$. The formulæ 16, 17, 18, and 19, are for calculating different parts connected with the hollow line, as will be understood by referring to Figs. 1 and 8. Should it be desired to be very fashionable, we can even form a wave-line by the parabolas.

THE HULL OF VESSELS.—The area A of the hull of a boat will be found by the formula 20,

Example 8. A vessel constructed with the exponents $n = n'' = 4$, Q = 307 square feet, $d = 12$ feet, L = 250 feet, and the area of the water-line $a = 5600$ square feet. Required the area of the immersed portion of the hull.

Formula 20. $$A = 2\sqrt{\frac{4}{4+1}}\left(307 + 12 \times 250\right) + 5600 = 11516 \text{ sq. ft.}$$

If the vessel is to be coppered, add 15 per cent. to the area A, and it gives the surface of copper required to cover the immersed portion of the hull, including the lap.

Example 9. A vessel of the same dimensions as in the preceding example has the upper deck 8 feet above the load water-line; the beam B = 28 feet, makes $d' = 12 + 8 = 20$ feet, and Q = 307 + 28 × 8 = 531 square feet, area of the upper deck, $a' = 6720$ square feet. Required the area of the hull from the keel to the upper deck.

$$A = 2\sqrt{\frac{4}{4+1}}\left(531 + 20 \times 250\right) + 6720 = 16{,}614 \text{ sq. feet.}$$

Example 10. Suppose the hull of the vessel in the preceding examples to be of ½-inch plate iron, and add 15 per cent. to the area A for lap and rivets. Required the weight of the hull in tons, from the keel to the upper deck.

$$A = 16{,}614 \times 1{\cdot}15 = 19{,}106 \text{ square feet.}$$

The weight of ½-inch iron is 20lbs. per square foot, when the weight of the hull will be

$$\frac{19{,}106 \times 20}{2240} = 171 \text{ tons nearly.}$$

Example 11. Suppose the distance between the frames to be 18 inches or 1·5 feet. Required the length of all the frames to the upper deck. From example 9 we have A = 16,614 square feet, when the length of the frames will be

$$\frac{16{,}614}{1{\cdot}5} = 11{,}076 \text{ feet,—the answer.}$$

Example 12. Required the depth of the centre of gravity in the hull of a vessel with dimensions, as in the preceding examples. The exponent for the cross section $n' = 10$. The bulwark and keel omitted. Length of upper deck L = 262 feet.

Formula 26.

$$d' = \frac{20\,(20 \times 250 + 5600 + 531)}{2 \times 20 \times 250 + 5600 + 2 \times 531}\left(\frac{10+1}{10+2}\right)\sqrt{\frac{4+1}{4+2}} = 11{\cdot}2 \text{ feet.}$$

It will be seen that the exponents perform the most prominent part, both in the calculation and construction. By proper selection of the exponents, any form of vessels can be constructed by the parabolic method.

The formula 21 is for calculating the horse-power necessary for a given speed; the co-efficient k will be found in Table I., last column, in the line of the given exponent for the displacement.

Example 13. What power is required for a vessel of dimensions as in the preceding examples to propel her M = 9 knots per hour? $n'' = 4$ $k = 1{\cdot}82$, Q = 307, and L = 250.

Formula 21. $$H = \frac{9^3 \times 307}{1{\cdot}82 \times 250} = 401{\cdot}8 \text{ horses.}$$

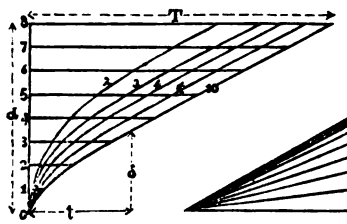

FIG. 4.

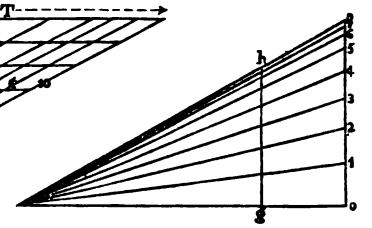

FIG. 5.

Fig. 3 is a scale of displacement at different drafts of water; it is calculated and constructed by the formulæ 13 and 14. The numbers on the curves denote the exponent n'' of the vessel, and not the index r. The displacement T is represented by the 8th water-line, from the figure 8 to where it meets the curve; all the other water-lines represent the displacement t at the noted draft.

Fig. 4 is a diagram for laying out the ordinates in the water-line and cross section; one of these should be constructed for each exponent n. This diagram is constructed with the exponent $n = 2$, the line $g\,h = b$, Figs. 1 and 2, and the ordinates in the inner parabola correspond with the distances from g in the diagram. It is constructed in the following way:—Make a right-angled triangle of any desired size; make the base longer than the height; call the height = 1; decide the exponent for the diagram; set off from the right angle the ordinates in the line b, Table I., and join them with the opposite angle in the triangle; then any beam b set off at right angle from the base to the hypothenuse gives the corresponding ordinates in the water-line or cross section.

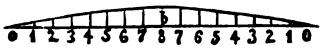

FIG. 5.

Fig. 5 shows how to lay out the spring of the beams; the length is divided into 8 equal parts from each end, numbered as shown by the figure. The spring of deck beams ought to be a parabola of the second order, when the ordinates are calculated from the line b, exponent 2, Table I. the spring $b = 1$.

(To be continued.)

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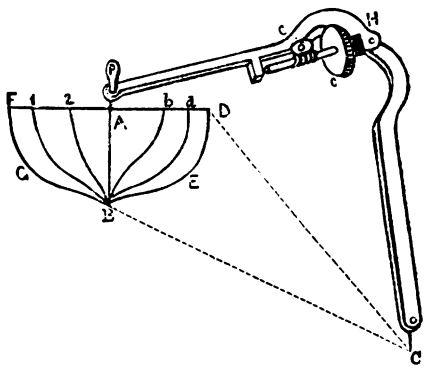
DESCRIPTION OF AMSLER'S PLANOMETER, AS APPLIED TO SHIPBUILDING.

This very ingenious and useful instrument seems to be but little known among engineers and constructors. It is a very important instrument in the construction of ships, where it saves a great deal of time and calculations; by applying the planometer to the frame drawing of a ship, the displacement is obtained correctly with only one multiplication, in a few minutes.

The accompanying figure represents Amsler's Planometer in position to take the areas of the immersed cross-sections of a ship. The instrument rests on three points, namely, A, C, and *e*; it has a hinge at H; the point C is stationary when the point P moves about; the wheel *c* turns in different directions, indicating the area described by P. The nature of the instrument is such that, when the point P moves from D via A to B, the wheel *c* indicates the area of the figure A, B, C, D; if P is moved further from B via E to D, the wheel *c* subtracts the area B, C, D, E.



leaving indicated the area A B E D. The wheel *c*, with the assistance of a *vernier*, gives three figures in the reading, and the wheel *e* moved by a worm-screw gives the fourth figure; the instrument gives a nicety of four figures in the reading, which is sufficient for most practical purposes.

The planometers are always made so that the point P is to be moved with the sun. However irregular a plan-figure might be, the point P moved through the whole boundary, gives the area on the whole *c* and *e*. The cross-section A, B, *b*, is obtained by moving P in the boundary from A via B, *b*, and back to A.

When it is desired to know the area of all the cross-sections, it is not necessary to read off every one of them, but continue to move through all the boundaries, and the wheels will add up the whole to one sum, which, multiplied by 2 and the distance between the sections, gives the displacement; though care must be taken not to take the greatest section *p* twice. Suppose all the areas of the figure before us is to be taken for the displacement: Move P from A to B *b* A, B *a* A, B E D A, further from A to 2, B A 1, B A, and the wheels will show the total sum of half the sections.

INSTITUTION OF CIVIL ENGINEERS.

STRUCTURES IN THE SEA, WITHOUT COFFER DAMS; WITH A DESCRIPTION OF WORKS OF THE NEW ALBERT HARBOURS AT GREENOCK.

By Mr. D. Miller.

It was stated that the immediate object of this Paper was to treat of the various methods of constructing the foundations of quays, walls, piers, or breakwaters, for the formation of docks and harbours, in deep water; and to describe works of this kind which have been carried out on principles different to those usually practised, and to point out the further application of those principles to other structures of a similar nature. The plans which had chiefly prevailed were, founding upon piling carried up to about the level of low water, constructing within caissons or coffer-dams, or building under water by means of diving apparatus. Instances of the failure of the first of these methods, which was believed to be inapplicable where there were marine worms, were given. The second was most effectual, but was generally expensive, and often attended with danger. The last was also costly, besides being subject to delay in the progress of the works. In bridge building, of late years, the plan of forming enclosures of close piling, of the shape of the pier, and filling in with hydraulic concrete, had been pursued by French engineers; and the substitution of iron for perishable timber piling, in the construction on this plan of the piers of the Chelsea and Westminster bridges, by Mr. Page (M.Inst.C.E.), was considered to be a successful departure from stereotyped rules.

Although the value of béton, or hydraulic concrete, was now appreciated in this country as a substitute for masonry, and had been employed in some important works, yet its use was chiefly confined to forming a homogeneous and monolithic bearing stratum for foundations, and not, properly speaking, as a constructive material. The modes in which concrete had been applied for constructive purposes were, building it dry in mass, and allowing it to set before being placed in the work, as had been adopted in the construction of the walls of the Victoria and of the London Docks; preparing it first in blocks, and allowing it to harden before being used, as employed at the Dover breakwater, and for the new sea forts at Portsmouth and Plymouth; and depositing it in a liquid state, and allowing it to set under water, as practised at the Government Graving Docks at Toulon. The facilities for making beton, which had the invaluable property of setting under water, and of thus forming an artificial rock or stone, were very great; as it might be made either from the naturally hydraulic limes, the artificially hydraulic limes, or cement, or from the rich or non-hydraulic limes, rendered hydraulic by the admixture of other substances, such as Puzzolana, minion, or iron mine-dust. Various examples were adduced of the application of concrete, on a large scale, prepared from these different materials, especially at the Mole of Algiers, at the breakwater at Marseilles, and at other French ports, as well as in the Pont d'Alma over the Seine, in which case both the arches and the piers were formed of rubble concrete.

As Engineers-in-chief for the new harbour works for the port of Greenock, the author and his partner, Mr. Bell, had an opportunity of introducing a system of constructing sea walls and quays in deep water, without the aid of coffer dams, diving apparatus, or other means equally expensive. These works were situated on the west side of the town, and had been projected almost entirely beyond the high water line into the sea. The outer pier would ultimately be upwards of 3000ft. in length and about 60ft. wide at the top, with quays on both sides. Within this there would be space for two harbours, each 1000ft. in length, 15ft. deep at low water, and 25ft. at high water, with entrances 100ft. wide, and ample room for the construction of graving docks, for the storage of timber, and for the erection of sheds. At present it was only proposed to erect about one-half of the sea pier, and to form one harbour or tidal dock. In the design of these works, it was suggested that the walls under low water should consist of a combination of cast-iron guide piles in the front, with a continuous stone facing, slid down over and enclosing these piles, timber-bearing piles being used in the body of the walls where required, and concrete backing being deposited in a soft state; and that the upper part of the walls should be built of masonry in the usual manner. The first operation, when the water was not sufficiently deep, was to dredge two parallel trenches to the required depth, 17 feet below low water, for the foundations. A staging of timber piles was afterwards erected in the line of the pier over its whole breadth, for carrying the tramways travelling cranes, and piling engines. The cast-iron guide piles were then driven from the staging, with great precision, 7 feet apart in the line of the face of each quay wall. These piles were driven until their heads were near to the low water line, by pile engines, furnished with long arms projecting downwards, strongly stayed by diagonals, and forming a trough, into which the pile was placed, and from which it was shot, like an arrow from a cross-bow. The piles were connected at the top transversely by wrought iron tie-rods stretching through the pier. When the piling was driven, a bed of hydraulic concrete, 3 feet thick, and 20 feet wide, was deposited in the trenches to form a base for the wall, and to give a large bearing surface. Into the grooves formed by the flanges of the iron piles, large granite slabs from the Ross of Mull, from 18 inches to 2 feet thick, were slipped, the bottom one resting on the concrete base, and on a projecting web cast on the piles. This constituted the face of the wall, and in each compartment between the piles, 16 feet in height and 7 feet in width, there were only three stones. Behind this facing hydraulic concrete was lowered, under low water, in large boxes having moveable bottoms, and was discharged in mass to form the body of the wall. To confine this at the back before it had set, loose rubble stones were deposited. The hearting of the pier consisted of hard till, stones, and granite up to the level of low-water. When the whole of this mass was consolidated, the heads of the iron piles and the granite facing blocks were capped by a granite blocking or string-course, and the upper portion of the walls was built in freestone ashlar and rubble. The remainder of the hearting between the walls was then filled in, and the whole finished with a granite coping and causeway. The walls were 33ft. in height from the foundations, 11½ feet thick at the concrete base, diminished by 5ft. at the top. In the part of the work already executed, the outer flange of the iron piles was exposed to the action of the salt water. In future it was intended to reverse this plan and to make grooves in the stone facing, so that it should over-

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lap the iron piles, filling in the grooves from the top with cement. When the whole extent of the seaward pier was completed, the interior operations for the harbour would be proceeded with; this pier serving as the principal coffer dam, and a short dam, about 100ft. in length, closing the entrance. It was stated that this mode of constructing walls in deep water without coffer dams had been most successful, and that a sea-pier of great solidity and durability had been formed in deep water at a comparatively moderate cost. The works of the Albert Harbour were being executed under the superintendence of Mr. John Thompson, as resident engineer, by Messrs. W. and J. York, contractors.

The application of this system to the construction of breakwaters and harbours of refuge, was then noticed, reference being first made to the principal modes of construction hitherto adopted, and to the peculiar phenomena by which such structures were affected. The usual method of forming breakwaters was by the *pierre perdue*, or long slope system, as carried out at Plymouth, Cherbourg, and Holyhead. Where stone was most abundant, a vertical wall was built from the bottom by means of diving apparatus, of which the breakwater at Dover, now in course of construction, was the most prominent example. Besides these systems, which might be taken as the extremes, an intermediate form of section, combining both, that was to say, a rubble mound to a certain depth under low water, and a vertical wall above, had been carried out at Alderney. From an examination of the general principles which affected breakwaters, and the modes of construction usually adopted, the conclusion arrived at was, that the vertical system was that which had best resisted, or rather averted, the destructive action of the sea, and required the smallest amount of material. Both the long-slope and the vertical systems, as at present carried out, were expensive, from the quantity of material used in the one case, and the costliness of the material and the mode of construction in the other; the former might be characterised as involving the maximum in quantity, and the minimum in cost of material; the latter, on the contrary, the mimimum in quantity and the maximum in cost of material. The object sought to be attained in the new system was to effect a minimum, as far as possible, both in the quantity and in the cost of the material. Breakwaters might be thus constructed, either wholly vertical from the bottom, or partially vertical, springing from a rubble mound. The principal feature of the new plan was a framework of iron piles, or standards, and ties, which would serve during the construction as the staging, and would afterwards form an essential portion of the structure, by binding together a strong casing of stone, or other sufficiently durable material, which would enclose and form the facing of the breakwater, the interior being filled up with loose rubble, cemented into a solid mass by liquid concrete. As soon as a pair of piles transversely had been fixed, rubble would be deposited up to, say, 18ft. under low water. Strong casing blocks, either of stone or of *béton*, made to enclose the iron standards, would then be lowered, the blocks being locked or arched into each other, so as to resist pressure from behind and made to break bond, if thought desirable. The hearting of the work would be proceeded with simultaneously with the building of the casing, and would consist of rubble in the centre, and of hydraulic concrete behind the stone casing. It was believed that such a structure could be erected in a depth of 6 fathoms, with a range of tide of 15 feet, for £190 per lineal yard, without a parapet, and at £200 per lineal yard including a parapet. The economy of this system would arise from the smallness in quantity and the cheapness of the bulk of the material. It would also possess the advantage of rapid execution, as the mass of the material could be deposited without any tedious operation being necessary over a great length of the work at one time.

The author was of opinion that the system which had been described admitted of being applied for the construction of the works under low water, of marine fortifications, as well as of breakwaters, piers, quay-walls, lighthouses, and other similar structures. He considered that, although the mode of constructing an engineering work must be determined greatly by local circumstanees, this system presented the following advantages—great economy, combined with strength and durability; facility and rapidity of execution; and adaptability to situations where the present modes of construction would be inapplicable.

ROYAL INSTITUTION OF GREAT BRITAIN,

ON ARTIFICIAL ILLUMINATION.

By EDWARD FRANKLAND, ESQ.

Ten years ago the speaker gave in this Institution a sketch of the condition of Artificial Illumination. Since that period but little progress had been made towards perfecting those processes of producing artificial light at that time in general use. Nevertheless, the improvments effected in the production and application of the electric light, the increase of our knowledge both of solar and terrestrial light, and especially the discovery of an entirely new illuminating agent, threatening to produce a revolution in lighting almost equal to that which was the result of the invention of gas—rendered it desirable again to review this subject, after the lapse of a decade.

In glancing at the improvements effected in the different departments of artificial illumination, those which relate to the Electric Light were first noticed. The electric light is produced by the interruption of an electric current flowing through good conductors; by this interruption the current is made to leap across a space provided in its circuit. The boundaries of this space, in the ordinary electric light, are formed by two portions of gas carbon, and during the passage of the electric current across it, the two pieces of carbon are heated to a most intense degree, and far beyond that produced by any other means at our disposal. The great source of illuminating power was shown to be the ignited ends of these two pieces of gas-carbon, and not the space between them.

Such being the nature of the electric light, the principal improvment which has been effected in it during the past ten years, consists in the production of the electric current through the intervention of heat and mechanical force by what is termed magneto-electricity. More than thirty years ago, Mr. Faraday produced a spark from the ordinary permanent magnet. Here, said the speaker (producing a magnet), is the very cradle of this magneto-electric light, and this is very magnet with which Mr. Faraday operated. This improvement constitutes one of the greatest steps in advance which have been made in the application and production of the electric light. By the combustion of coal a certain amount of mechanical power is obtained, which is applied to the rotation of masses of iron in the neighbourhood of very powerful permanent magnets. In this way, currents of electricity are produced, and these are thrown together, and made to circulate through a system of conductors: in fact, there is no difference, as regards the effect at the carbon-prisms, between the action of this magneto-electric current, and the ordinary electric current produced by the chemical action which takes place in the voltaic battery. But this improved mode of producing the electric force demands less manual labour, the mechanical work being performed by a steam-engine, which causes the rotation of the armatures.

This magneto-electric apparatus, as perfected by Mr. Holmes, has now been in use for upwards of two years in the South Foreland and Dungeness Lighthouse, where, as well as in other similar beacons, the production of a light of the greatest intensity is of the greatest importance to the mariner. During this time it has performed its office remarkably well, and without a single instance of failure, thus proving itself well adapted for the purposes of lighthouse illumination.

For domestic light it has not been yet brought into use, its expense, doubtless, at the present moment, being far too great to admit of its being employed in this way; but where a light of great intensity, regardless almost of the question of expense, is required, as in the case of lighthouses, the magneto-electric light can scarcely be too much prized.

The speaker also described the mercurial electric light, but considered it inferior both in brilliancy and steadiness, to that procured by the passage of the electric current between carbon terminals.

The discoveries and improvments connected with gas as an illumination agent were then considered. It is of great importance that gas, as light-giving material, should be improved to the utmost possible extent, so as to make it a perfect source of light. Its conveniences are so patent to every one, its use is attended with so few discomforts, and the light is obtained with such facility, and of any desired intensity with certain limits, that there is, perhaps, no source of artificial light capable of such general application. Nevertheless, this is one of the modes of illumination which, having been long previously in use, has not made great progress during the past ten years. The sulphur compounds, which at the commencement of that time were complained of being present in purified gas, are still there in considerable, if not in undiminished quantity, although there has recently been a process devised by means of which these impurities can be, to a great extent, got rid of. It remains to be seen whether this process be applicable, on a large scale, in the gas manufactory; but, so far as can be judged from experiments made upon a small scale, it is a process which is likely to be very effective. It is the invention of the Rev. Mr. Bowditch, of Wakefield. These sulphur compounds are irremovable in the ordinary process of purification. The gas may be passed in the usual manner over hydrate of lime, or the peroxide of iron; but this operation does not, in the slightest degree, affect the sulphur compounds in question; during the combustion of the gas, however, their sulphur is converted into sulphurous acid, which diffuses itself into the apartment in which the gas is burned, and a great deal of the discomfort of which many complain in the use of gas is due to this cause. Mr. Bowditch discovered that though cold hydrate of lime will not remove impurities, they are to a great extent got rid of by heating the hydrate of lime to a temperature varying from the boiling point of water up to 400° or 500° Fahr., a temperature of 400° being the most convenient for the development of the effects of his process, The heated hydrate of lime converts the sulphur compounds into sulphuretted hydrogen and carbonic acid, which can then be removed by the ordinary purifying material—cold hy-

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drate of lime. This process has been found by repeated experiments to remove all but about 2 or 3 grains of sulphur per 100 cubic feet of gas, the quantity of sulphur originally contained in the gas varying from 5 or 6 grains up to 20 grains in 100 cubic feet. Heated hydrate of lime was shown to develope sulphuretted hydrogen from the gas supplied to the Institution.

Another recently ascertained fact in connection with gas is the discovery of an illuminating constituent recently made by M. Berthelot. This is a gaseous body, called Acetylene, which is produced under very peculiar circumstances. Unlike all other hydrocarbons with which we were formerly acquainted, an intense heat is favourable to the production of this body. For instance, it is produced when coke is very intensely ignited in hydrogen gas; and Dr. Odling has recently demonstrated that two of the constituents of coal-gas, light carburetted hydrogen and carbonic oxide, which are useless for lighting purposes, may, by means of strong ignition, be made to form acetylene, and thus become luminiferous agents. It has generally been considered important to preserve a moderate degree of heat in gas-making, in order to prevent the destruction of the luminiferous hydrocarbons; but the discovery of the formation of acetylene, under the circumstances named, will render it necessary to investigate how far the production of this substance can be carried on upon a large scale, and rendered valuable for increasing the illuminating power of gas. The subject is yet in embryo, but it has an important bearing upon the future progress of gas-lighting. Acetylene and olefiant gas contain, in equal volumes, the same amount of carbon, but the former contains only half as much hydrogen as the latter; consequently, the illuminating power of acetylene is probably at least double that of olefiant gas.

The compound of acetylene with copper, is a substance not altogether devoid of interest to the gas-manufacturer. When it attains a certain heat, it explodes with considerable violence, and the same effect may be produced by friction. It has been demonstrated recently, that acetylene, of copper can be produced by the passage of ordinary coal-gas, containing as it does, a trace of ammonia, through copper or brass tubes; and explosions which have taken place through cleaning out such tubes, resulting in serious injury to workmen, have been doubtless due to the presence of this substance. It is of course obvious that an explosion of this kind, even if slight in itself, may be communicated to explosive mixtures of gas and air (in a gas-holder or gas-meter, for instance), and may thus lead to very disastrous results. An explosion of this kind occurred a few years ago in Lancashire. A large meter had been detached and brought into the open air; a workman was unscrewing one of the brass connections, when the meter exploded with a loud report. The explosion could not be accounted for, as all the eye-witnesses were positive that no ignited body of any kind was near the meter.

The improvements effected in the production and application of oils for illuminating purposes were next referred to.

The animal and vegetable oils, which for ages have been employed for this purpose, have received no development of importance during the last ten years. On the other hand, new sources of this class of illuminants have been discovered, which threaten to produce a great revolution in the modes of obtaining artificial light.

One of the most important of the materials manufactured from these sources is paraffin-oil, the production of which from bog coal has been carried out on an immense scale with great ingenuity and success by Mr. Young, of Bathgate, near Edinburgh.

This new source of light is, however, already threatened by a formidable rival—native coal oil—which has been distilled by nature herself, and consequently does not require those preliminary processes which oil produced from bituminous coal has to undergo. These discoveries have been made principally in the United States of America, and more especially in Canada. In the latter country alone no less than twenty millions of gallons of this oil have been obtained from wells, several of which are spouting-wells. From these the oil rises, probably from the pressure of gas, to a considerable height above the surface of the ground, so as not to require pumping. The twenty millions of gallons, which represent the annual productions of the Canadian wells, may, upon a moderate calculation, be said to furnish, in refined oil alone, illuminating material equal to one hundred and eighty millions of pounds of sperm candles.

The importance of such a vast amount of illuminating material so cheaply obtained can scarcely be overrated in connexion with the question of the production of artificial light. Up to the present time, the refined oil from this crude petroleum has been prevented from coming into effective competition with the original paraffin-oil, owing to the carelessness with which the former has been manufactured. There is a considerable portion of light naphtha left in this oil, which renders it capable of forming explosive mixtures in the lamps wherein it is burned. Both these American oils require to be still further freed from volatile naphtha; they would then form valuable illuminating materials.

The speaker then directed attention to the following tables. The first contains the results of his experiments on the illuminating effect of these oils in connection with that of some other materials used for giving artificial light:—

Illuminating Equivalents, or the Quantities of different Illuminating Materials necessary to produce the same amount of Light.

Young's Paraffin oil	1 gallon.
American rock oil, No. 1	1·26 „
„ No. 2	1·30 „
Paraffin candles	18·6 lbs.
Sperm „	22·9 „
Wax „	26·4 „
Stearic „	27·6 „
Composite „	29·5 „
Tallow „	36 „

From this table was made the following calculation of the comparative cost, from different sources, of the light of twenty spermaceti candles, each burning for ten hours, at the rate of 120 grains per hour:—

	s.	*d.*
Wax	7	2½
Spermaceti	6	8
Tallow	2	8
Sperm oil	1	10
Coal gas	0	4½
Cannel gas	0	3
Paraffin	3	10
Paraffin oil	0	5
Rock oil	0	6½

Thus, from an economical point of view, the rock-oil and the paraffin-oil approach gas much more closely than any other illuminating agent hitherto invented, while the enormous quantities in which these oils are now being produced, cannot fail to make them still lower in price. They may consequently be regarded as very formidable rivals of gas-light.

The following table contains the carbonic acid and heat generated per hour by various illuminating agents, each giving the light of twenty sperm candles:—

	Carbonic acid. cubic feet.	Heat.
Tallow	10·1	100
Spermaceti Wax	8·3	12
Paraffin	6·7	66
Coal gas	5·0	47
Cannel gas	4·0	32
Paraffin oil Rock oil	3·0	29

This table shows to what extent the atmosphere of rooms is deteriorated by these illuminating agents. It shows also that, from this point of view, paraffin and rock-oils stand out as the best sources of light.

The chemical and physical laws upon which all modes of artificial illumination depend were then referred to. Every method of artificial illumination depends upon the heating of certain bodies to such a temperature that they become incandescent. With gases this temperature is much higher than liquids and solids. There is only one instance in which the incandescence of vapour is used, and that is the mercurial electric light, already alluded to. In all other cases the incandescence of solid bodies is employed. In the ordinary method of obtaining the electric light, the incandescence of solid prisms of carbon is the source of luminosity. In gas and oil flames, it is the incandescence of little particles of carbon, and in all these cases the light is produced from solid matter. The luminosity of any flame depends, first, upon the number of solid particles which exist in it at any given moment; and, secondly, upon the temperature of the flame. The number of solid particles is dependent upon the nature of the flame itself, whether it be a flame produced by the burning of bodies rich in hydrocarbons, or by the burning of bodies which are poorer in this respect. Such a flame is always affected by the pressure of the atmosphere; the higher the pressure of the air, the greater the number of luminous particles of carbon present at one time in the flame. If, after the barometer has been standing at 30 inches, it falls to 29 inches, the light of all flames is reduced to the extent of about 5 per cent. The temperature, upon which the luminosity of a flame also depends, may be increased by heating both the gas and the air supplied to it for combustion, before they are brought together to be burned.

The speaker exhibited a gas lamp which he had constructed to effect this object. It consisted of an ordinary argand burner, with glass chimney, but furnished with an outer glass cylinder resting upon a solid plate of glass, through the centre of which the tube supplying the gas ascended. Thus all the air supplied to the flame was compelled to pass down between the chimney and outer cylinder, becoming thereby strongly heated before it reached the flame, whilst considerable heat was also imparted to the gas before the latter issued from the burner. In this manner a great increase of light, with the same consumption of gas, was obtained.

The following table was exhibited, showing the effect of this hot air gas-burner in reducing the consumption of gas for a given amount of light, and thereby also the impurities and heat which are thrown into the atmosphere in which such a lamp is burned

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	Rate of consumption per hour.	Illuminating power.
Argand burner supplied with cold air	3·3 cubic feet	13 sperm candles.
	3·7 „	15·5 „
	4·2 „	17 „
Same burner supplied with hot air ...	2·2 „	13 „
	2·6 „	15·5 „
	2·7 „	16·7 „
	3·0 „	19·7 „
	3·3 „	21·7 „

For an equal amount of light, the saving of gas = 33 per cent. For an equal consumption of gas, the gain in light = 62 per cent.

The temperature necessary to render substances incandescent may be imparted to them in various ways. It may be given directly by mechanical power, as in the "steel mills," formerly used in coal-mines. Usually however, chemical action is employed, as in gas, candle, and oil-flames; or electricity is used, as in the various forms of electric light.

The conditions necessary for a good and satisfactory artificial light were now examined. In the first place, the light should contain all colours; that is, it should be capable of showing every variety of tint which will be exposed to it. This is the case with the carbon electric light, and that of candle, oil, and gas flames, since the light from these sources contains all the colours of the spectrum. But there are many colours which the mercurial electric light is incapable of showing, since they are absent from its spectrum. It was also shown that all pure colours, except yellow, were perfectly black, when seen by the light of incandescent sodium vapour.

Solar light, although in so many respects superior to artificial light, is defective as regards the showing of colours. There are certain colours which cannot be seen by solar light—for instance, all the colour which can seen by the sodium flame is quite invisible in daylight. If a pigment could be made of such a yellow colour as to be of exactly the shade of that produced by the same sodium flame, it would be absolutely black in solar light. But our pigments are all mixed colours and no such pigment which thus entirely disappears in the light of the sun is known. But in addition to this tint of the sodium flame, there are hundreds of other tints which are also not present in the solar spectrum, and which are consequently invisible in daylight.

Although solar light is inferior to artificial light in the completeness of its colours, yet, in another respect—in the comparatively small amount of heat which accompanies its rays in proportion to the light itself—it is greatly supperior to every sort of artificial light. The great amount of heat in our artificial lights is absolutely useless. It is nearly all intercepted by the humours of the eye before it reach the retina, and, no doubt, produces that irksomeness which is felt after working in artificial light for any considerable time, and which is not experienced from daylight.

The speaker concluded as follows:—The history of artificial illumination cannot fail to impress upon us the difficulties in the way of the application of scientific discovery to the utilities of life. How long was it after the discovery of the production of gas from coal, before a manufacturer could be found to bring it into actual operation? Thirty years ago, working in his laboratory at Blansko, Reichenbach showed us the process by which we could obtain paraffin and paraffin-oil from bituminous coal; but the discovery remained unheeded for twenty years. More than thirty years ago, Mr Faraday pointed out a source of the electric light in the permanent magnet; but we are only now beginning to use it for illuminating purposes. The brilliant little spark was long looked upon as a mere scientific curiosity, and is only now beginning to flash across the sea, guiding the mariner safely into harbour, or warning him from approaching a dangerous coast. How long will thermo-electricity have to wait before it receives a similar application? In thermo-electricity we have a direct transformation of the force of heat, which we obtain with such great economy from coal, into an electric current, and this, by further education and development, might be rendered available in the production of the electric light. Hitherto, its application in this direction has been altogether unheeded, and yet, of all sources of power necessary for the electric light, thermo-electricity evokes this power most directly from coal. In the magneto-electric light we have the great disadvantage, that the heat of burning coal must be first transformed into mechanical power, which is made to rotate the armatures of magnets, and thus produce the necessary electric current. In this transformation of heat into mechanical power there is no less than 9-10ths of the original force in the coal absolutely lost. Hence the advantage which would result from the direct application of heat to the production of the electric current.

The man of science rejoices in the discovery of truth for its own sake. He give his results freely to the world. It is no part of his duty, it is not his function, to apply those truths to the utilities of life. Success in this direction demands quite different powers of mind. Those who possess these powers ought also to acquire the necessary knowledge which would enable them, with more facility, to seize upon the discoveries of science, and apply them to the wants of every-day life. This scientific knowledge is the link which, up to the present time, has so sadly failed in the application of science to the manufacturing arts.

ON FOGS AND FOG SIGNALS.

By JOHN HALL GLADSTONE, Esq., PH.D., F.R.S.

During the course of the inquiry made by the Royal Commission on Lights, Buoys, and Beacons, the attention of my colleagues and myself was called to the fog signals which form part of the apparatus of many lighthouses, and of all British light-ships. In the report we expressed our conviction, "that they are not sufficiently powerful, and recommend the provision of a more efficient warning in fog as subject of investigation and experiment." About the same time, some scientific men in Ireland stirred in the matter, and induced the British Association to appoint a committee, at the head of which is the Rev. Dr. Robinson, of Armagh, to bring the importance of the subject more directly under the notice of the legislature. These circumstances led me to turn my attention to fog; and I propose now to lay before you some of the results arrived at, with reference both to the meteorological phenomenon itself, and to the means adopted for preventing its disastrous consequences among the vessels that sail along our shores.

I have received voluminous returns of the occurrence of fog at about 250 stations, for which I am indebted to the kindness of the three general Lighthouse Boards,—the Trinity House, the Northern Commissioners of Lighthouses, and the Ballast Board of Dublin; also to the Board of Trade, through Admiral Fitz-Roy; and to Mr. Glaisher. I wish here also to express my thanks to several gentlemen who have aided me in the preparation of this discourse, especially Mr. Alexander Cuningham, who has just read a paper on the subject at the Royal Scottish Society of Arts, and to our friend Professor Wheatstone.

FOGS.

A fog is simply a cloud resting on the earth. In the first discourse of the present season, Professor Tyndall explained the formation of clouds from the aqueous vapour in the atmosphere; and defined a cumulus as "the visible capital of an invisible column of saturated air." A fog is the capital without the column. It is the moisture evaporating from the warm earth, or river, or sea, condensed at once by the colder air. Mr. Glaisher told us here how, from his lofty position in the balloon, he saw a fog following all the windings of the Thames. This is a frequent observation, and it reminded me of a scene from the summit of the Righi one morning last summer. There lay in the valley of the Reuss a mist like a white sheet on the ground, but as the sun began to exert his power, and a light breeze to spring up, the uniform layer began to break into regular masses, and soon far beneath us there stretched a cirrus cloud, identical in aspect with those we so often see in the highest regions of the atmosphere.

Fog, then, is composed of minute particles of water, most likely in a globular form, for there seems to be no ground for the popular notion of vesicles of vapour. Smoke enters largely into the composition of that peculiar yellow fog which visits London a few times each year,—a fog of wonderful darkness and quietness, and strangely bewildering.

This condensed vapour has a great effect in obstructing the passage of light; the sun himself cannot look through it. A slight mist seems to attack principally the more refrangible rays of the spectrum, so that the light appears redder than usual. I once analysed with a spectroscope the rays which reached Worthing from the great revolving light on Beachy Head, twenty-eight miles distant, and found that those only situated between Fraunhofer's lines C and F were transmitted. This was on what would be called a clear summer night. An objection has been raised against the orange-red glass used in many of the French lighthouses, that in misty weather all bright lights are reduced to very nearly that colour, and thus the distinction is lost; a misfortune that could hardly happen with the deep-red glass employed for the red lights of the British Isles. When the sun shines through a cloud or mist, we do not detect those atmospheric lines which make their appearance when his disc is near the horizon. Yet I have observed in London, when the sun at a considerable altitude loomed red through a slight fog, that the characteristic C δ, δ, and η were visible.

There is, of course, every conceivable gradation between the lightest haze and the densest fog, and it is a difficult matter to draw a line of distinction between fog and mist. The value of the meteorological returns in my possession depends greatly on this, and there is reason to fear, even from internal evidence, that one lighthouse keeper calls by the name of fog what another keeper thinks sufficiently described as mist or haze. Yet these keepers have a certain general sentiment and similarity in their way of thinking, and with many the practical definition of a fog is when it is necessary to sound the signal. Among amateur observers on land the greatest discrepancy prevails; but nautical men seem to have a general agreement as to what amount of thickness is to give a claim to the designation fog. For such observations Mr. Cuningham suggests that a pole, painted vermilion, should be set up at a hundred yards from the station, and that such an amount of mistiness as renders it invisible should alone be named fog. The colour of the pole should, of course, be in strong contrast to the objects behind it. This definition is somewhere about that practically adopted by seamen; it has been accepted by Mr. Glaisher, and it is to be hoped that it will be generally adopted by all observers.

From the returns received, the following deductions may be drawn:—

1. While many fogs are quite partial in their character, others cover a large extent of country. The irregular distribution of a London fog is a matter of frequent observation. Thus, on Tuesday, the day of the royal wedding, one of the densest yellow fogs obscured Westminster, while at Bayswater there was nothing more than a murky mist. The long-continued fog of November last in London, extending from the 19th to the 25th, was observed also at Berkhampstead, Oxford, and Banbury, but other parts of England seem to have been clear. The occurrence of fog at the lighthouse stations all round the coast during the first six months of the year 1861 has been especially studied, and the fogs of that April have been represented on a map. Some of them cover large portions of the British Isles. For instance, that of the 14th stretched all round Ireland,

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except the south-west corner, crossed the Irish Sea to the headlands of Wales and the south-western isles and coasts of Scotland, and made its appearance again across the mainland in the Firth of Forth.

2. Some months are marked by fogs much more than others. For instance, along the south coast of England, February and September are comparatively free, while January and June are foggy months. November is notorious for fog in London, but does not seem to deserve that character elsewhere.

3. Some years are much more visited by fogs than others. For instance, 1861 was freer than 1858 along most parts of the coast.

4. Different localities are very variously visited by fog. England does not deserve that pre-eminent character for mistiness which is attributed to it by the popular imagination of the Continent. The value of the returns in showing the relative distribution of fog in different places is seriously affected by the different standards in the minds of the observers, but the following points seem pretty clearly made out:—A fog is more uniformly distributed over the surface of the sea than on the adjoining coasts. Fog is not particularly prevalent about sand-banks, or low headlands; but where cliffs or high hills catch the south-west wind just after it has swept the ocean, as at the Isle of Wight, the Start Point, Lundy Island, and the Rocks of Pembrokeshire, the numbers run very high. The highest return is from Barra Head, the southernmost point of the Hebrides, where winds surcharged with moisture from the Gulf Stream strike the cold northern rocks, and wrap them in cloud or fog.

Fog Signals.

As light only very imperfectly penetrates a fog, attempts have been made to warn vessels of their approach to danger, or to acquaint them with their position, by means of sound. The fog signals actually in use are as follows:—Bells are employed at many of the lighthouses, and in the Irish light-ships, the finest, perhaps, being two near Dublin, and that at the Copeland Island, in the Irish sea, which is rung by machinery, and is said to have been heard thirteen miles off. At the end of the pier at Boulogne there is a large bell, in the centre of a large parabolic reflector facing the sea. It is struck by three hammers alternately, the motive power being a falling weight. Gongs are made use of in all the light-vessels belonging to the Trinity House. Guns are fired on board the *Kish* light-ship, from the mountain above the South Stack Lighthouse, at Fleetwood, and elsewhere. A very powerful steam-whistle has for some time been in operation at Partridge Island, near St. John's, New Brunswick, a part of the world peculiarly affected by fog.

At the Skerries, near Holyhead, terns and other sea-birds are encouraged, as their cries serve as a warning to vessels during fog; but unfortunately some rats escaped from the *Regulus*, which was wrecked there about seven years ago, and they are destroying the birds. A cat has been tried, but she preferred birds to rats.

The comparative efficiency of these various methods is a very serious question; indeed, there are grave objections to the use of sound at all as a fog signal. The difficulties are as follows:—A sound indicates the proximity, but not the exact direction, of a danger. In this respect it is totally different from a light. Yet the mere warning is something; and probably a suitable ear-trumpet would give a better idea of the direction than is obtained without it. There is evidence that vessels have sometimes steered by a sound; for instance,—"In the winter of 1860, the steamer *Iron Duke* having been drawn by the flood tide to the northward past Howth, was attracted by the sound of the bell, and steered by it safely towards Kingston, until the bell on the east pier of that harbour told her of her proximity, and ultimately led her into safety." The Royal Commissioners on Lights made special inquiry about the Boulogne bell, and found that some of the captains of steamers frequenting that port could find their way in by the sound of the bell, in thick weather; at least, in conjunction with the use of the lead.

An objection to the use of most of these fog signals is the fear that they may be mistaken for other sounds, or other sounds mistaken for them. Bells are frequently being rung on shipboard; the firing of guns is the well-known sign of distress; and steamers in a fog are in the habit of whistling as they go along. Gongs do not seem open to this objection; and in the case of other sounds, it might be obviated by having a definite system of repetition, as is done with the flashing and revolving lights. My friend, the Rev. T. Pelham Dale,* has indeed suggested a means of signalling, in which musical notes are employed.

Another difficulty is, that even loud sounds cannot be heard far to windward if a breeze is blowing; bnt this is of less importance, as a fog usually occurs in calm weather.

But the great objection to sound as a fog signal is, that a fog stops the waves of sound as it does those of light. It is well known that sound will not traverse a heterogenious medium, such as air loaded with mist. As to the fact of such signals being rendered inefficient by the very thing which they are intended to penetrate, the testimony of mariners is somewhat conflicting. Mr. Alexander Cuningham, who is the secretary of the Northern Commissioners of Lighthouses, says:—"Many years ago, having landed from the lighthouse tender on the small skerry in the Portland Firth, a fog came on. We hurried off in the hope of reaching the vessel; but before doing so, the fog shut her completely from our view. We pulled in the direction (having a compass) in which the tender was last seen; but those who know the variety and rapidity of the tides in that dangerous locality will easily be prepared to hear that our efforts were unsuccessful. We lay about the spot for some time, firing our fowling-pieces, and at last pulled for the shore. Next morning the vessel came in sight; and on comparing notes, we found that we must have been within a very short distance of her; and they had been firing small six-pound carronades all night, and we never heard them, nor did those on board hear our guns."

Yet, on the other hand, we have accounts of bells being heard at a distance of some miles during a fog, and the steam-whistle near St. John's is said by the captains and pilots of steamers frequenting that port to be most serviceable, and to be generally heard for four or six miles during strong breezes blowing on shore. It is, indeed, quite possible that fogs of the same intensity may still have a very different effect upon the same signal, and that for two reasons; first, one fog may reach far up into the atmosphere, presenting a high wall to every vibration; while another may be a thick layer lying on the surface of the earth, with an open space above, through which the swelling waves of sound may freely pass. Secondly, air perfectly saturated with moisture is no bad conductor of sound; a fog under such atmospheric conditions may therefore be far less obstructive than when the medium is more heterogeneous.

Considering these objections to the use of sound as a fog signal, must we abandon it altogether? We cannot do so, as we have nothing better to substitute. We fall back upon the recommendation of the Royal Commission, that further experiments should be made, which it is hoped will be gradually adopted by the authorities, as the majority of the other scientific recommendations have been.

Experiments should be performed on the manner and degree in which fog absorbs or destroys sounds of different pitch, or of different characters,—for instance, a sharp sound or a prolonged sound; on the various means of producing loud sounds, as to their pitch, volume, convenience, costliness, &c.; whether a repetition of the same sound, or some variation in note, octave, frequency, &c., be desirable; on the influence exerted by the height above the sea at which the sound originates; on the influence of a background, such as a tower, cliff, or hill, in reflecting the sound, or of a concave mirror; on the best means of directing a sound to a particular azimuth, or of determining its direction when on board ship.

Captains Close and Nisbet, of the Trinity Board, have made some experiments on one of these points at Holyhead Mountain, where a gun was fired from near the surface of the sea, and another at a considerable height, and the respective reports were listened to from various distances at sea. They found the upper gun was heard best for six miles, after which it lost its superiority But the most remarkable result was the irregularity of the noise from the lower gun, which, at certain points, in fact, was not heard at all, though the flash was distinctly seen.

Powerful means of producing sound, besides those already mentioned, have been suggested. Mr. Cowper has planned a large steam-trumpet for lighthouse stations, which may be made to revolve. There is something similar in America worked by Ericsson's engine, with which is associated the name of Mr. Daboll. And Professor Holmes, of the Magneto-Electric Light, has also a steam-trumpet, which can be adapted for different notes, and gives a buzzing sound of wonderful intensity. Suggestions on this point were also made to the Royal Commissioners by several scientific men. Thus, horns were strongly recommended by more than one; but Mr. Mallet prefers explosive sounds; and Sir John Herschel says:—"It would be worth trial, what would be the effect of a battery of whistles, blown by high-pressure steam, or by a combination of three, or several sets of three, pitched exactly to harmonic intervals (key-note, third, fifth, and octave), but all of a very high pitch, and with a rattle (analogous to the pea in a common whistle), which intensifies the action on the auditory nerve." Captain Ryder believes a gun might be constructed to produce the very distinctive sound of an explosion, followed instantaneously by a whistle.

There is another and very promising field for experiment, the transmission of sound through the water itself. The experiments of M. Colladon on the Lake of Geneva proved the great distance to which sound is transmitted through water, and the velocity and directness of its course.*

In his observations he employed a bell, let down into the water; but this is a bad instrument for signalling, as its vibrations are almost instantly stopped. Many arrangements would appear to be preferable. The Syren, which was so called by its inventer, M. Cagniard de la Tour, because it would sing under water, is well adapted to give any note that is found desirable.† Long glass tubes, vibrating longitudinally, are said to produce immense volumes of sound in water: and other means might be devised. As the sound remains in the water, it would be necessary to make some communication between it and the ear of the listener. M. Colladon employed an apparatus like a spoon, with a tube for handle. By this means a mariner might listen for signals made at any important station, such as the Lizard Point, and might not only hear them at a great distance, but determine approximately their direction, unaffected by the state of the atmosphere above.

* "Marryatt's Signals," ed. 1856.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.

On the evening of Saturday, the 14th of March, the tenth anniversary of the formation of the above-named society was celebrated by a dinner at the Bay Tree Tavern, St. Swithen's-lane, City. Mr. Keyte, of the firm of Messrs. Shears and Sons, of Bankside, presided on the occasion, and about sixty members and friends of the association were present. It had been determined some months previously to present to the President a testimonial in recognition of the services he had for many years past gratuitously rendered to the society, and the celebration of the anniversary was considered the most appropriate time for the ceremony. Mr. Joseph Newton, who for the last five years has occupied the honourable post named, was accordingly the principal guest at the dinner. After the usual loyal and patriotic toasts has been duly proposed and responded to, and that of "Prosperity to the Association" had been given by the chairman of the evening, Mr. Keyte proceeded to present to Mr. Newton the testimonial. This consisted of several articles of plate, the principal of which were a salver of considerable dimensions, an inkstand of chaste design, a goblet, and a liqueur stand. In very complimentary terms these were formally presented to the President by Mr. Keyte, who concluded his remarks by proposing the health of the recipient, which was heartily responded to.

* Mémoires de l'Acadamie des Sciences: Des Savans Etrangers.—Tome v.
† Ann. Chim. Phys. xii., page 171.

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UNITED STATES GUN BOATS.

As a great deal has been said about the gun-boat flotilla of the United States, we herewith give for the information of our readers three views of one of these vessels, showing the general arrangement of the boilers and machinery.

Our illustrations are taken from the plans furnished by the United States Navy Department to the several shipbuilders and engineers, who were called upon to send in estimates. Fig. 1 being a tranverse section of portion of the hull, Fig. 2 a longitudinal section, and Fig. 3 being a part plan, Fig. 1 being drawn to an enlarged scale. We regret and are surprised to find that such a very objectionable form of boiler should have been selected for this purpose. We allude more especially to the height of the top of boiler above the water line. This will be apparent to the most inexperienced person, on reference to figs. 1 and 2.

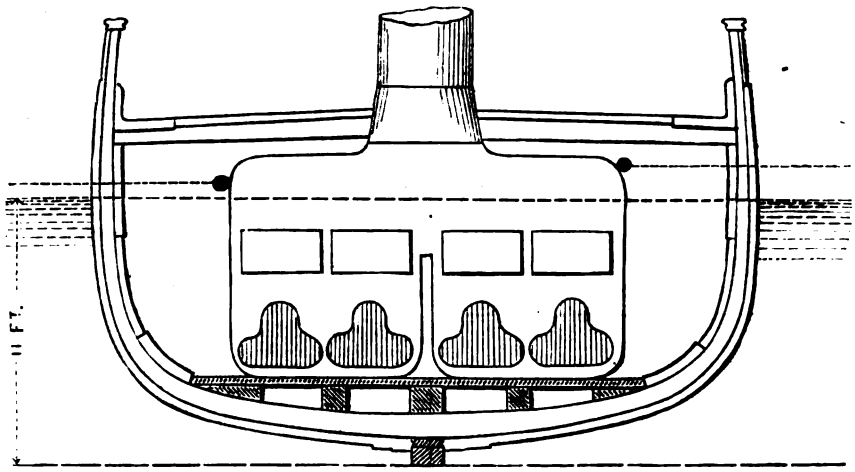

FIG. 1.

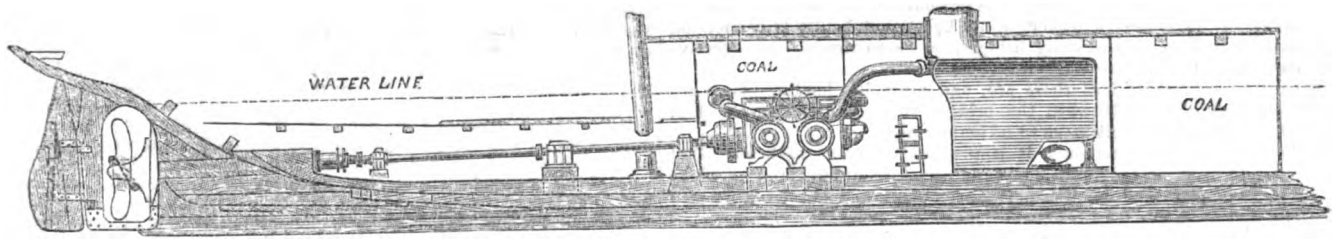

FIG. 2.

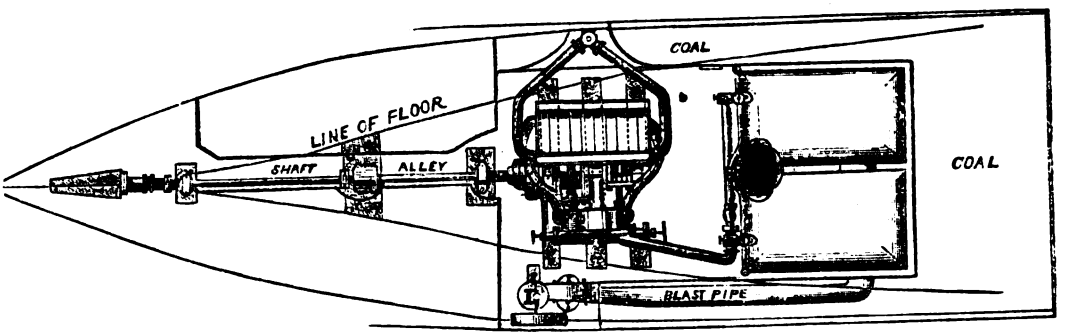

FIG. 3.

TRIAL OF THE IRON-CLAD FRIGATE, "PRINZ EUGEN" (AUSTRIAN NAVY.)

We learn from the *Triester Zeitung* that on the 25th of March the iron-clad frigate *Prinz Eugen* underwent a 12 hours' trial, with a view to test the working of the engines, which had been supplied by the Trieste Technical Establishment. A trip was made from Pola to the Muggia Bay and back. The engines are a fac-simile of those working on board the iron-clad frigates *Kaiser Max* and *Don Juan d'Austria*, supplied by the same establishment. The following are the chief particulars as to dimensions, &c., of the engines, viz.:—Nominal horse-power, 650; cylinders 74in. diameter; stroke, 39in. There are 6 tubular boilers, each of them having 5 furnaces; the aggregate heating surface is 13,000 square feet.

The working of the engines was highly satisfactory. The greatest indicated horse-power, computed from diagrams most carefully taken during the trip, is 2838 horse-power, *i.e.*, 4·4 times the nominal power. The average number of revolutions was 53, the maximum, 57 per minute, at which speed the engines worked without interruption during several hours, without any apparent sign of straining of the parts, thus bearing evidence to their excellent workmanship and their correct proportions. The average speed of the frigate during the whole trial of 12 hours, was computed at 12 nautical miles per hour. From the Muggia Bay to the entrance of the harbour of Pola she took only 5 hours, and a length of 4·75 nautical miles, viz., from Pirans to the Salvore Lighthouse was done in 22 minutes, being a speed of nearly 13 nautical miles per hour, the indicated horse-power of these engines being 4 times the nominal horse-power.

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The iron-clad frigates of the Austrian Navy were designed by and erected under the superintendence of the I. R. Chief Engineer, Herr Romako, and reflect considerable credit upon him as a naval architect. The following is a return of the engines built for the Austrian Government at the Trieste Technical Establishment during the last eleven years.

	Pairs of Engines.	H.P.	
1851-57	1	100	for I.R. steamship *Taurus*.
„	1	40	for I.R. steamship *Alnoch*.
„	1	180	for I.R. steamship *Prinz Eugen*.
„	1	300	for I.R. frigate *Donau*.
„	2	230	for I.R. corvettes *Dandalo* and *Erzherzog Friedrich*.
1858	1	800	for I.R. line-of-battle ship *Kaiser*.
1859	3	50	for I.R. gunboat for the *Lagunes*.
1860	3	90	for I.R. gunboats *Kerka, Narenta, Sansego*.
„	6	90	for I.R. gunboat for the *Gardu Lake*.
1861	2	90	for I.R. gunboat *Gemse and Grille*.
„	2	500	for I.R. iron-clads *Drache* and *Salamander*.
„	1	500	for I.R. frigate *Novara*.
1862	3	650	for iron-clads *Kaiser Max, Prinz Eugen*, and *Don Juan d'Austria*.
	27	6470	Total horse-power.

THE THAMES EMBANKMENT.

In a report to the Metropolitan Board of Works, Mr. Bazalgette says,—"The total length of the embankment is about 7000 feet, but it is completely divided by the bridges into three sections, each of which will be viewed by itself, and the line of vision will not ordinarily be continued from one section to the other. The first section is from Westminster to Hungerford Bridge, the second from Hungerford Bridge to Waterloo, and the third from Waterloo to Blackfriars Bridge.

"A continuous line of embankment wall would not in itself be productive of much architectural effect: the present landing-places for steamboats are exceedingly ugly, and there would be much difficulty in connecting the river wall with the existing bridges, so as to produce an effective and consistent design.

"At each of the bridges there are, and must be, landing-places for steamers; and midway between the bridges there are landing-places of some description, which will have to be maintained.

"To meet these requirements, it is proposed to treat each length of embankment from bridge to bridge as a complete design, and to make the steamboat-piers and landing-places prominent and effective, as well as useful and necessary features.

"At Westminster Bridge, the roadway, which rises at an inclination of 1 in 80 to the level of the bridge, is set back some 30 or 40 feet from the face of the embankment wall; and the intervening space would be preserved as a promenade and steam-boat pier, having access from the bridge by a wide and imposing flight of steps opposite the Houses of Parliament. This will terminate without abruptness the varying styles of architecture at this point. Between Westminster and Hungerford Bridges would be the landing-stairs for small craft; and here it is proposed to introduce the beautiful water-gate now situate at the end of Buckingham-street, and erected after a design of Inigo Jones. On either side of Hungerford and Waterloo Bridges would be steamboat landing-piers, the dummies for which would be partly concealed within recesses formed by projecting into the river, in front of the general line of embankment, massive granite piers with moulded pedestals rising about 30ft. above the roadway, and hereafter to be enriched with bas-reliefs and surmounted by groups of statuary.

"Half way between Hungerford and Waterloo bridges it is proposed to construct a flight of landing steps 60ft. wide, projecting into the river, and flanked at each end with massive piers, rising to the level of a few feet above the roadway, and hereafter to be surmounted with colossal figures of river deities, or other appropriate groups. It is proposed to form an approach for foot passengers from the high level roadway to the river by a second flight of steps, descending to the level of the lower or embankment roadway, which would add much to the effect of this central feature as viewed from the river. On either side of this approach, a line of shops could be erected on the land side of the embankment roadway, the backs of which would form a retaining wall to the ornamental crescent and promenade above them.

"Between Waterloo and Blackfriars bridges, and in front of Arundel-street, a steamboat pier would be constructed, in lieu of the present Essex-street pier, designed upon the same principle as those adjoining the bridges.

"The embankment wall itself has been enriched with mouldings of a simple character, down to the level of high-water mark, the continuous line of moulding being broken by the introduction, at intervals, of massive blocks of granite, to carry ornamental lamps, and by occasional recesses for promenade seats.

"It is proposed in the first instance to construct the embankment wall and fill in behind it to the level of 4 feet above Trinity high-water mark, and afterwards to arrange for the laying out of the area reclaimed. I propose to divide the work into two contracts, the first from Westminster to Waterloo Bridge, which may be let about the end of May or early in June; and the second from Waterloo to Blackfriars Bridge, which may be let before August next."

The number of houses required to be taken for the construction of the Thames Embankment on the north side of the river, situate in Printer's Street, Huish Court, Currier Row, Jackson's, Canterbury, and Green Dragon Courts, in St. Anne's Blackfriars, amounts to thirty-two, consisting of tenements containing from three to eight rooms, and the number of persons to be displaced thereby 437, children included. The number of houses to be taken for the construction of the Southern Embankment in High Street, Vauxhall, Princes Street, Upper and Dower Streets, and Stangate, in Lambeth, is we understand, 124, including seven model lodging-houses, and calculated to displace 1,175 persons, including children.

REVIEWS AND NOTICES OF NEW BOOKS.

London and its Gas Companies; State and Condition of the Companies supplying Gas to the Metropolis, described in a letter to Her Majesty's Principal Secretary of State for the Home Department, with references to the first accounts made out by each Company, in accordance with the Metropolis Gas Act, 1860. By SAMUEL HUGHES, F.G.S., C.E. Waterlow and Sons, 49. Parliament Street, and 66, London Wall, E.C.

This pamphlet contains a complete and comprehensive examination of the present financial condition of the London Gas Companies, showing their absolute proportional capital, their incomes from various sources, and their expenditure under appropriate heads. The working out of these statistical details has evidently been a work of great labour, and is based upon the accounts made out by the Companies themselves, in accordance with a form prescribed by the late lamented Home Secretary, Sir George Cornewall Lewis, under the provisions of the Metropolis Gas Act, 1860. An attentive perusal of this pamphlet will show conclusively the great benefits which the Metropolis Gas Act has placed within the reach of gas consumers. The author points out in the clearest manner, that if the capital of certain extravagant companies be reduced to that of more economical ones, the profits realised by the whole of the companies, would vary from 11 to 16 per cent., according to the companies which are taken for comparison. Under these circumstances, it appears that on every principle of justice and common sense, the gas consumers throughout the metropolis, are entitled to a large reduction of price, inasmuch as the companies are expressly limited under the Gas Works Clauses Act, to a dividend of 10 per cent. The Phœnix and the South Metropolitan Gas Companies, have already been compelled by the operation of the Act, considerably to reduce their prices, and it only requires action on the part of the consumers to compel a corresponding reduction all over the Metropolis.

It is evident, however, that the working of the Metropolis Gas Act and the carrying out of its ample provisions, can no longer be entrusted to the Vestries and District Boards of the Metropolis. These wretched bodies are for the most part so much occupied with their own petty internal squabbles, and in other cases are so much under the influence of Gas Companies and creatures in their interest and employ, that the real interests of the gas consumers are entirely neglected by them. Out of the thirty-nine vestries and district boards constituted under the Metropolis Local Management Act, probably not more than ten have complied with the provisions of the Gas Act, requiring them to provide apparatus and appoint an examiner to test the quality of the gas supplied in their respective districts. Of course this conduct is perfectly illegal, and we presume it is in the power of any ratepayer, by applying to the superior courts, to compel these public bodies to comply with a duty expressly assigned to them by Act of Parliament.

That the magnitude and importance of this question may not be misunderstood, let us direct attention to the long contest which raged during the Metropolis Gas Inquiry, relative to the illuminating power which should be fixed as the standard for the London Gas Companies. The standard which the companies contended for, was that of 12 wax, or rather more than 10 sperm candles, whilst the promoters of the Bill insisted on, and eventually obtained, a standard of 12 sperm candles. The difference between 10 and 12 candles, may therefore be considered the limits within which the gas of the metropolis fluctuates, and a reference to the tables in Mr. Hughes's pamphlet readily enables us to estimate the importance of the question. By reference to table at page 4, we find the aggregate gas and meter rental of all the companies supplying within the metropolitan area, amounts to £1,411,780, and deducting from this £15,653 received for meter rental, there remains for gas alone a yearly rental of nearly one million four hundred thousand pounds.

Now, if the whole of the gas supplied to the metropolis be 10 candle gas instead of 12, it will be found by a simple rule-of-three sum that the metropolis would be paying to the gas companies more than £280,000 a year in excess of the proper amount. It is not intended to report positively that this is actual loss to the metropolis arising from the supply of inferior gas, but it must be observed this would have been, in round numbers, the result of the companies' own proposal as to illuminating power.

The public may be left to judge whether the companies in the absence of examiners and apparatus for testing their gas, are not very likely to relapse into

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their own old and favourite standard, in which case, as already shown, the loss to the metroplis would approach £330,000 a year. The same kind of apathy was displayed by the Vestries and District Boards with reference to the sale of Gas Act, which insures to the public the certainty of correct and reliable meters. Fortunate for the gas consumers of the metropolis, that these effete and venal bodies were not entrusted with the carrying out of this Act, which was happily assigned to the Metropolitan Boards of Works, and has ever since been acted on with much vigour and effect.

Mr. Hughes complains that the capital accounts of the London gas companies have hitherto been subject to no such scrutiny, or investigation, as that which took place into the analogous accounts of the water companies in 1851, when the committee, which sat on the subject, referred the investigation of the capital accounts to an accountant who went into the matter in great detail. Had this been done in the case of the gas companies we should not be presented with the anomalies which are now brought to light by Mr. Hughes, who shews that some of the London companies have nearly three times the proportionate amount of capital which suffices for other companies.

Besides the general control given to the Secretary of State, under the metropolis Gas Act, it appears the individual gas consumers have extensive powers under the provisions of the Gas Works Clauses Act, which is incorporated with the Metropolis Gas Act.

By Section 35, of the Gas Works Clauses Act, any two gas rate payers may petition the Quarter Sessions to appoint an accountant, or competent person, to examine and ascertain, at the expense of the gas company, the actual state and condition of the concerns of the company and make a report thereon to the Court. Then follows a provision empowering the Court to reduce the price of gas in case it shall appear, after due investigation, that the profits have exceeded the prescribed rate, which, in the case of the metropolitan gas companies, amounts to 10 per cent. per annum. This power of examination could be most readily exercised by any of the local boards, or vestries, under the Metropolis Management Act, as these are all gas rate payers in respect of the public lamps.

These bodies, however, have hitherto shewn such a complete apathy and such a fixed disinclination to trouble themselves, in any way, for the good of the private gas consumer that any action on their part seems hopeless.

At the same time we urge the attention to this subject of individual consumers, the remedy being trifling and expensive, while it is scarcely possible to conceive, the good which might be effected by speedy and energetic action. Every days experience painfully reminds us of the contrast between the metropolis and the great centres of industry in Lancashire and other parts of Great Britain. Considering the quality of the gas supplied in Lancashire the price is less than one half of that which is charged in the metropolis, while in Birmingham, Bristol, and other large towns the consumers are much dissatisfied with prices far below those of London, and energetic efforts are now being made in introducing new companies in these and other large towns.

Apart from its direct value to the gas consumers, of the metropolis, as shewing them the actual working of all the companies, this pamphlet abounds with valuable tables, which possess the greatest interest and value, in a statistical and engineering point of view, for all those who are desirous of learning the conditions under which new gas companies can be profitably established.

Under this aspect the table at Page 11 is extremely interesting, as it shews, for every one of the London companies, the ratio which the capital bears to the tonnage of coal used in the works. It appears that the aggregate capital of the whole thirteen companies amounts to £5,602,900, and that every £636 of capital represents 100 tons of coal. This is the aggregate working of all the companies, but taking the two extremes there is a wide range of difference. For instance, the Independent Company works with £427 of capital for each 100 tons of coal used in the year; while the London company has £866, or more than double the amount, for each 100 tons of coal. Mr. Hughes shews that five of the principal companies have an average capital of less than £500 for each 100 tons of coal.

We may also direct attention to the tables at pp. 26 and 27, where the whole of the receipts and expenditure of all the thirteen companies are worked out in the most perfect manner and reduced to a standard price per ton of coal.

These tables afford the utmost facilities for calculating all the elements both of old and new gas works as they are founded on the very large basis of a capital represented by nearly six millions sterling, and are, therefore, of much higher value than the experience derived from smaller works.

Viewed in this light the able exposition of these accounts and the accompanying tables will be found of the highest value to all directors, managers and secretaries of existing gas works, and ought to be carefully studied by all who profess to work economically. Their value in the case of contemplated, or new companies, has been already alluded to.

To show the imperfect and erroneous statistics which are frequently circulated, in reference to gas supply, it might be mentioned that in a popular diagram of gas works, issued a few years ago by a publisher in the Strand, it is stated that the consumption of coal for gas making, in the metropolis, equals 350,000 tons per annum. Now Mr. Hughes shows from an examination of the accounts which he has made, that in the year 1861 the consumption of coal for gas making was equal to 882,000, or more than double the above amount, and this, be it observed, is exclusive of a group of nine companies, which are situate on outskirts of the metropolis, and supply partly within and partly without.

In conclusion we strongly recommend this pamphlet to all those who are any way interested either in the establishment of new gas companies or in the working of old ones.

The following works are to hand, too late for notice in our present number, viz.:—

Willson's Science of Ship-building. London: J. D. Porter, 31, Poultry.
Holmes's Magneto-Electric Light, as applicable to Lighthouses.

NOTICES TO CORRESPONDENTS.

S.—Yes; but we have received your note too late to enable us to give the Admiralty order you refer to in our present number. We will insert it in our next.

"ELASTICITY."—It is intended to embody the particulars to which you refer.

P. O.—Mr. John Seaward was born in 1786, and died March, 26th, 1858. Amongst the engines built by Messrs. Seaward and Co. for steamships in H.M. Navy may be mentioned the *Volcano, Megæra, Alecto, Promstheus, Ardent, Polyphemus, Driver, Styx, Vixen, Geyser, Growler, Montezuma, Firebrand, Penelope, Avenger, Sidon, Leopard, Blenheim, Hogue, Conflict, Horatio, Nile, Termagant, Caradoc,* and many others of less importance. At the same time they adapted their engines to many large vessels for the Hon. East India Company, for the Steam Navigation Companies at home, as well as for various Governments and companies abroad.

RECENT LEGAL DECISIONS
AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

UNDER this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

APPLICATION FOR PROLONGATION OF PATENT, *Bovill.*—The Judicial Committee of the Privy Council recently set in this case. A petition for a prolongation of Bovill's patent for grinding corn (part heard) was concluded. The Master of the Rolls gave judgment on the part of their lordships, granting an extension for five years. The lords present were the Master of the Rolls, the Lord Chief Justice Erle, and Sir E. Ryan.

MARTIN *v.* GRAY.—MINING CASE.—Mr. Thomas Martin, a merchant, of Wadebridge, sued Mr. Thomas Gray, colonial broker, of London, as a partner in the Messer Mine, for goods supplied to the mine. Mr. Collier, Q.C., in stating the case, said that the plaintiff supplied goods, from the order of Captain Rich, the manager of the mine, to the extent of more than £200, chiefly coals and things absolutely necessary to work the mine; all of them were used in the mine, and helped to realise such gains as were obtained. A fair quantity of ore was raised, and the mine paid its way for some time, but not altogether. The plaintiff, acting as a prudent man, never would have supplied the goods but for Mr. Gray's visit to the mine, and the interest he took in it. This was not a limited liability concern, or a joint-stock company, but a private partnership, in which each partner was liable for the debts of the company, and could recover a contribution from the other partners. Mr. Gray was sued because he was the only substantial man in the concern, those associated with him being merely men of straw. Captain Rich, the captain of the mine, was the principal witness against the adventurer. The defence was that Mr. Gray had advanced money to Gregg, a shareholder in the mine, and had gone to see it, as he had an option to become a shareholder, but did not do so. Mr. Gray stated that the whole of his advances amounted to upwards of £1000, not one farthing of which has yet been returned. Mr. Gregg stated that he had received the money from Gray as loans, and contradicted some of the statements of Captain Rich. Mr. M. Smith, Q.C., having summed up the evidence for the defence, Mr. Collier, for the plaintiff, replied upon the case. He said that this was a case of great importance, as it was an endeavour to put forth an optional partnership—if the mine was successful Mr. Gray was to be partner, but if it was not then Mr. Gray had nothing to do with it. If such an optional partnership was to be tolerated, there would be a complete change in commercial affairs. The learned Judge (Mr. Justice Byles) then summed up the whole case to the jury. He said the sum claimed amounted to £236 13*s.* 4*d.*, without interest. This was a case of very great importance to the parties, and, he might almost say, to the public. It was a case of considerable importance to the plaintiff, because he had unquestionably supplied these goods, and it did not seem, so far as could be collected, that he was likely to be paid in any other way. It was of great importance to the defendant, because he had derived no profit, but a very great loss, from his connection with the mine to which those goods were supplied, and very intelligible hints had been thrown out in the course of this enquiry that this was but the precursor of many other like demands upon him. He was sure this case had received their most attentive consideration. They had had the advantage, and he had had the advantage, of hearing this matter discussed by very able counsel, who were just as able as any men in England to dissect evidence, and to show how the various parts of it bore one upon the other. Partly for that reason, and partly owing to the great pressure of business, his address to them would be very short. He would not trouble them with many observations on the conflict of evidence, but would content himself with telling them the questions for their determination, and make one or two observations on the leading and salient points of the case. After carefully going through the evidence, his Lordship told the jury that if they thought the defendant Gray had stipulated, when he made either of the three advances, that he should have a share in the profits of the mine he was liable; and if he did not so stipulate, yet held himself out to the world and the plaintiff as a partner, and if plaintiff trusted him, he was liable. If, on the other hand, they were of opinion that he had no interest in the mine except the option of taking shares in it, and that he never had these shares or anything at all to do with them, but was a mere creditor, and nothing more, they would find for defendant, as they also would if they thought the goods were not supplied on the credit of the defendant, and not of the machinery. The jury gave a verdict for the plaintiff for £236 13*s.* 4*d.*, without interest.

THE MID-LEVEL COMPENSATION CASE.—A Norwich special jury, under the presidency of Lord Chief Justice Earle, have recently been for five days engaged in investigating an action—Coe *v.* Wise, Clerk to the Mid-Level Commissioners—for negligence in not making and maintaining the outlet sluice of the Mid-Level, by reason of which the tidal waters broke through and ran over the sluice, submerging the plaintiff's land. The importance of this trial may be estimated from the fact that no fewer than 107 compensation claims, involving about £70,000 damage, have been awaiting its decision. At the close of the trial the Lord Chief Justice put it to the jury—First, was damage caused to the plaintiff by the absence of due skill and care on the part of the defendant in making the sluice; secondly, in maintaining the sluice; thirdly, in providing remedies against mischief after the sluice was destroyed; and, fourthly, by reason that no puddle clay wall was made along each side of the banks of the cut? The verdict was returned for the defendant on the first issue, and for the plaintiff on the three last issues—virtually a verdict for the plaintiff. The question of damages will be settled out of court.

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NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparationi necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention-Chemistry as applied to the Industrial Arts Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

The Largest Carriage Manufactory in the World is that of a Berlin company, formed for the supply of railways. Last year it is said to have employed 1552 men, and to have made sales to the amount of about £270,000. It delivered during the last year 290 railway passenger carriages, 993 goods waggons, 187 post, military, and other various carriages. It began the new year with orders rendering it pretty certain that this year will exceed the last in prosperity. Considerable deductions have been made for reserve fund, &c., a dividend of 8¼ per cent. has been declared.

The Paris Permanent Exhibition.—*Le Siecle* gives the following account of the progress of the palace which is being built in Paris for an universal and permanent Exhibition, and of which all the cast iron works have been sent from Glasgow:—"The winter has been so mild that the building of the Auteuil Palace has been uninterrupted, and is now far advanced. The stone work is fully 30ft. high, and a good many columns and girders have already been set up. All the heavy iron works are on the spot, and that is the most important thing of all. It is a most curious sight to see the workshop where the iron pieces are turned and finished, and thence removed on railway trucks, and raised by travelling cranes to the places they are to occupy. That shop alone employs 370 men and 28 engines. The dome will be the principal feature of the building, and next in importance will be the front entrance, which forms an arcade 70ft. high and 50ft. wide, surmounted by a group of figures of 15ft. The building will have another door of equal size, with fewer ornaments, besides eight smaller ones. In a formal notice we stated that other buildings would be annexed to the Palace, each for a specific purpose. In a few days they will begin to lay the foundations of one of these supplementary buildings, which is intended for the exhibition of machinery, and will measure 400ft. in length and 120ft. in width.

Tools at Woolwich.—A contract has been entered into between the Admiralty and Messrs. Smith, Benock, and Tannett, the machine tool-makers of Leeds, for the supply of their special machinery to Woolwich Dockyard, for the purpose of planing, shaping, drilling, and slotting the armour-plates still to be attached to the iron-cased ship *Caledonia*, and also those of the corvette *Favourite*, ordered to be completed forthwith. The machinery, although on a much larger scale, will be similar in most respects to that employed with success in Keyham Dockyard and the manufacturing departments at Woolwich Arsenal.

NAVAL ENGINEERING.

Trial of the "Royal Oak."—The official trial of the *Royal Oak* took place on the 26th March last. On getting under way the *Royal Oak's* draught of water was found to be 23ft. 1in. aft, and 20ft. 4in. forward, which was somewhat less than on the previous day. Six runs were made at the measured mile at full speed, the following being the results:—In the first run the time was 5min. 30sec., the speed in knots was 10·909, the number of revolutions of engines 60, and the pressure of steam 21; in the second run the time was 4 min. 13 sec., the speed in knots 14·229, the number of revolutions of engines, 59, and the pressure of steam, 19½; in the third run the time was 5 min., 30 sec., the speed in knots, 10·909; the number of revolutions of engines, 60, and the pressure of steam, 20; in the fourth run the time was 4 min., 18 sec., the speed in knots, 13·953, the number of revolutions of engines, 59½, and the pressure of steam, 20; in the fifth run the time was 5 min., 30 sec., the speed in knots, 10·909, the number of revolutions of engines, 59, and the pressure of steam, 19; in the sixth run the time was 4 min., 17 sec., the speed in knots, 14·008, the number of revolutions of engines, 61, and the pressure of steam, 20. In all the runs the vacuum forward and aft was 24. The mean speed of the six runs was 12·487 knots. The engines of the *Royal Oak* are of 800-horse power (nominally), while those of the *Black Prince* are 1250-horse power, and yet on the occasion of the last trial trip of the latter vessel she only attained a mean speed of 12·209 knots, the *Royal Oak* thus beating her by a quarter of a knot an hour. The actual displacement of the *Royal Oak* during her trial was 6500 tons, and this mass was driven through the water at a speed greater than that attained by the largest of the iron frigates, with the exception of the *Warrior*. At the termination of the runs at full speed, it was determined to try the vessel at half-boiler power, and four runs were accordingly made at the measured mile, with the following results:—In the first run the time was 6 min. 45 sec; the speed in knots, 8·89; the number of revolutions of screw, 47; and the pressure of steam, 19; pitch of screw, 27ft. 6in. In the second run the time was 5 min. 9 sec.; the speed in knots, 11·650; the number of revolutions of screw, 49; and the pressure of steam, 20; pitch of screw, 27ft. 6in. In the third run the time was 6 min. 29 sec.; the speed in knots, 9·254; the number of revolutions of screw, 47; and the pressure of steam, 20; pitch of screw, 27ft. 6in. In the fourth run the time was 5 min. 46 sec.; the speed in knots, 10·405; the number of revolutions of screw, 47; and the pressure of steam, 20; pitch of screw, 27ft. 6in. In all the runs the vacuum fore and aft was 24. The average speed of the four runs at half-power was 10·140 knots. At the termination of the trials of speed some experiments were made in order to test the time in which the half-circle would be made. Four runs were accordingly made, with the following results:—First run, helm put hard a-starboard, with four men at the wheel, and the rudder at an angle of 18 deg., half circle made in 2 min. 29 sec.; second run, helm at port, and rudder at 17 deg., half circle made in 2 min. 34 sec.; third run, helm at starboard, half circle made in 2 min. 42 sec.; fourth run, helm at port, circle made in 2 min. 39 sec. At half-boiler power the helm was put hard a-starboard by four men with three turns of the wheel, and the rudder at an angle of 15½ deg., when the half-circle was made in 3 min. 40 sec., the screw making 39 revolutions per minute, and the diameter of the circle 300 yards. The helm was then put hard aport, at an angle of 14½ deg., and the half circle made in 3 min. 32 sec. Commander Crewe-Read, who superintended the trials, then directed the helm to be put hard a-starboard to an angle of 18 deg., and the ship going at full speed, with the screw, making 54 revolutions, the complete circle was made in 6 min. 38 sec., the diameter of the circle being a little more than double the vessel's length.

Trial Trip of the "Anglia."—The present fleet of the Atlantic Royal Mail Company is now completely ready for sea, and in a condition to commence immediate operations, the fourth of their large paddle-wheel steamers, the *Anglia*, on the 10th ult., having made a most successful official trial at the measured mile in Stokes Bay. Like her sister ship, the *Columbia*, this vessel has been materially strengthened and improved since her first build, Messrs. Laird and Sons, of Birkenhead, having executed the work connected with the hull, while the machinery department was placed in the hands of Messrs. Ravenhill and Salkeld, of London. The *Anglia* ran the measured mile four times with the following results:—1st run, 4m. 16s., equal to 14·063 knots per hour; 2nd run, 4m. 26s., 13·533 knots; 3rd run, 4m. 22s., 13·740 knots; 4th run, 4m. 16s., 14·063 knots; revolutions of engines throughout, 21. This gave a true mean of 13·742 knots per hour, being about a quarter of a knot faster than the speed attained by the *Columbia*, although the two vessels are alike in every respect. During the trial the pressure of steam was 26lb., and vacuum 26 inches, force of wind 3. She had about 900 tons weight of coal, water, &c., on board. The draught of water was 19ft. 8in. forward, and 19ft. 4in. aft. After leaving the measured mile the *Anglia* was turned round while at full speed, completing the circle in 7 minutes 35 seconds. Every portion of the machinery worked admirably, and very little vibration was felt in any part of ship when she was running at the highest rate of speed. The Government surveyors present expressed their perfect satisfaction with the *Anglia's* performances during the trial.

Trial of the "Sparrow."—The screw steam gun vessel *Sparrow*, 5, was taken outside the breakwater, Plymouth, on the 11th ult., to test her engines and machinery, preparatory to her departure for her station on the West Coast of Africa. She is of 430 tons burden, is built of wood, and, being fully equipped for sea, draws 11ft. 3in. aft, and 10ft. 6in. forward. The maximum speed attained with full boiler-power was 10·2 knots; the average, 9·817 knots; with half boiler-power, 7·041 knots. This result is considered highly satisfactory, and will bear comparison with that of any other ship of the same class. The number of revolutions per minute was 105. The helm in still water can be put over to 31 deg.; but when the rudder is in vigorous action the force of the sea upon the steering tackle reduces it to 27 deg. A circle was performed under full speed in 4m. 13s.; with half boiler-power, 2m. 20½s. The engines possess 60 horse power, and are from the manufactory of Messrs. Napier.

Trial Trip of the "Leander."—The *Leander*, 51, 2760 tons, 400-horse power, was taken from her moorings in Sheerness harbour on the 15th ult., for the trial of her machinery at the measured mile off Maplin Sands. The trial was not quite successful, owing to excessive priming, and the vessel was therefore taken out again on the following day, when a completely successful trial was made, with the following results:—True mean speed at full boiler-power, 10·448 knots per hour; revolutions—maximum 57, mean 55 to 56 per minute; pressure of steam, 20; vacuum, forward and aft, 24; draught of water, fore 19ft. 9in., aft 21ft. 11in.; temperature—main deck, 56 deg.; engine-room, 68 deg.; stokehole, maximum 110 deg., minimum 74 deg. The vessel is fitted with Griffith's screw, pitch 24ft., length 3ft., immersion of upper edge 2ft. 5in.

The "Pandora," 4, screw, has completed her trials of speed at Portsmouth with full and half boiler-power, realizing a mean speed in knots with the former of 8·528, and with the latter of 5·430. At the full boiler-power trial the temperature ranged:—On deck, from 51 to 58 deg.; in the engine-room, from 65 to 70 deg.; and in the stokehole, from 80 to 95 deg.

Trial Trip of the "Conqueror."—The screw steam line-of-battle ship *Conqueror* (late *Waterloo*), 86, 2845 tons, 500-horse power, was, on the 17th ult., taken from her moorings in Sheerness harbour to the measured mile off Maplin Sands for trial of her machinery, after being brought forward and placed in the first division of the steam reserve some months ago. The results of the trial are as follow:—True mean speed at full boiler-power, 9·935 knots; half boiler-power, 8·126 knots per hour; revolutions, maximum 63, mean 61·3 per minute; vacuum, fore 24¼, aft 23; draught of water, fore 23ft., aft 24ft. 9in.; temperature, on deck 58 deg., engine-room 74, stokehole, maximum 104, minimum 94. The circle was made at full boiler-power, with helm port 17 deg., in 6m. 30s.; revolutions, 54 per minute; the diameter of circle being 500 yards at half boiler-power, with helm starboard 20 deg., in 6m. 27s.; revolutions 50 per min., diameter 400 yards. The half circle was turned at full speed in 4m. 29s., and at half speed in 3m. 40s. She is fitted with Griffith's propeller, pitch 20ft., but variable from 17ft. to 22ft.; length 3ft. 9in., diameter 18ft. The trial was made in a smooth sea, with the force of the wind very slight. It was perfectly satisfactory.

The Trial of the Iron Screw Steam Transport "Orontes," 3, recently built for the Admiralty by Messrs. Laird, Birkenhead, took place outside Plymouth breakwater on the 16th ult. The trial was under the supervision of Captain Astley C. Key, C.B., and Mr. A. Dinnen, inspector of machinery from the guardship of steam reserve, Indus, in Hamoaze. The weather was very fine. The *Orontes*, which is built entirely of iron, and has her lower mast stepped, has a burden of 2812 tons, and draws 17ft. 11in. aft and 17ft. 3in. forward. The engines, direct acting, are of 500-horse power nominal, but were worked up to 2020-horse power; cylinders horizontal; diameter, 31in.; stroke, 36in. The screw shaft is about 110ft. long by 13in. diameter. The screw is Griffith's shifting; diameter, 18ft.; pitch, 25ft. The mean speed obtained from six runs was 13·292 knots, which, when it is recollected that the ship had been in the water since the beginning of December, and that her bottom could not consequently be clean, is considered very fair. The maximum number of revolutions was 63 per minute; the mean number of revolutions at full power 61½; the pressure 25lb. to the square inch. There were no indications of hot bearings or of priming. The engines of the *Orontes* are similar to those of the *Prince Regent*, *Sanspareil*, and *Barossa*, by the same manufacturers. This transport has accommodation for 1150 troops. The trial under steam appears to confirm the anticipations of her good qualities for speed expressed when she was launched on the 22nd of November last at Birkenhead.

The "Black Prince," 40, iron frigate, coaling in No. 10 dock, at Portsmouth, will be undocked about the 4th inst. Her bottom has been scraped over, and it is now ordered to be coated with the McInnes composition on one side, and with the composition prepared by Mr. Hay, the Admiralty chymist, on the other, in order to obtain a comparative result of their respective merits. A good deal of corrosion is visible in places, but the most serious injury exists on the third streak of plating below the armour-plates. These results forcibly illustrate the danger which must always attend the use of copper compositions, as at present applied to the bottoms of iron ships. For about 40ft. along this streak of plating, where the vessel is broadest, there run straight lines of indentations irregular in number, averaging about an eighth of an inch in width, and at their greatest depth about the sixteenth of an inch. The ship has here evidently rubbed against some-

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thing, possibly the staging alongside the dockyard on first leaving the dock, and scraped through the composition to the surface of the iron, and this done a powerful battery has been at once formed, the power of which to destroy the ship was only a question of time. In the instance of the *Black Prince* this power has been arrested, but it is a proof that all iron ships coated with copper preparations require frequent docking to ascertain whether the outer surface of the composition is undisturbed.

TRIAL OF THE "HEBE."—The trial trip of this twin screw steamer took place on the 25th ult., between the Nore and Mouse lightships. The *Hebe* is the third vessel on this principle which has been built and engined by Messrs. Dudgeon of the Isle of Dogs. The performances of the first two—the *Flora* and the *Kate*—have already been noticed in our columns. The *Hebe* is an iron vessel, of 470 tons, 165ft. long, 23ft. beam, 13ft. 6in. deep, having a deck house 7ft. high extending about three-fourths of her length, fitted up with cabin and saloons. Draught of water at time of trial, 5ft. forward and 9ft. aft. Being without dead weight to give her sufficient immersion, the vessel was under considerable disadvantages, especially as there was a strong wind blowing, which materially retarded those revolutions which formed the principal feature of interest to most present. The screws were three-bladed, 7ft. 6in. in diameter, with 15ft. pitch, worked by two separate and independent engines, having each two cylinders 21in. in diameter, with 26in. stroke of pistons, and 120 collective nominal horse power. The revolutions at the time of trial between the lightships were 110. The time occupied between the Mouse and Nore lightships was 33 min. 15 sec., the distance being eight statute miles. Among the evolutions performed for the satisfaction of the scientific gentlemen present, were the following:—1. Full speed ahead with both screws helm hard a starboard; circle completed in 4 min. 2. Full speed ahead, both screws, helm hard aport; 3 min. 40 sec. 3. Helm a starboard, with port screw stopped; circle completed in 3 min. 9 sec. 4. Circle made the reverse way by putting the helm aport and with starboard screw stopped, in 3 min. 38 sec. 5. Helm hard aport, the screws being turned in opposite directions, the vessel pivotted on her centre in 3 min. 52 sec. 6. A second experiment the reverse way was made in 4 min. 10 sec., the mean time of these last two revolutions being 4 min. 8 sec. 7. Helm amidship, the screws working in opposite directions; the circle was completed in 4 min. 58 sec. The engines varied alternately in these trials from 90 to 103 revolutions per minute. As before mentioned, during these experiments a fresh wind prevailed, which materially retarded the turning, the vessel being light, and consequently exposing a large area to the wind. The engines worked admirably throughout, the boilers giving an abundance of steam, and the whole of the arrangements were excellent, reflecting great credit on the builders. We may add that during the trial luncheon was served on board in very excellent style by Mr. G. J. Atkins, of the World's End Tavern, Tilbury. Mr. Atkins is becoming deservedly well known as a caterer upon such occasions.

THE TRIAL OF THE "JASEUR," 5, screw steam gun vessel, 425 tons, 80 horse power, commissioned for service on the West Coast of Africa, took place at the measured mile off Maplin Sands on the 21st ult. The trial was most satisfactory. The following were the results:—True mean speed at full boiler power, 8·398 knots per hour; revolutions, maximum, 102, mean 99 per minute; pressure of steam, 20lb., and vacuum gauge, 25¼. At half boiler power the true speed attained was 6876 knots; revolutions, maximum, 87; mean, 81¼. The circle was made at full boiler boiler, helm starboard 35 deg., in 4 min. 7 sec.; revolutions, 92: diameter of circle, 200 yards; at half boiler power, helm starboard 35 deg. in 5 min. 17 sec.; revolutions, 73; diameter, 300 yards. The half circle was made at full boiler power, helm port 28 deg., in 2 min. 16 sec.; helm starboard 31 deg., in 1 min. 48 sec.; at half boiler power, with helm port 31 deg., in 3 min. 30 sec., and with helm starboard 32 deg., in 2 min. 57 sec. The vessel was started full speed ahead in 4 sec., and stopped in 6 sec. She was started full speed astern in 7 sec., and stopped in 6 sec. The force of wind was from 5 to six; and the draught of water, forward, 10ft. 8in.; aft, 12ft. The pitch of the screw was 12ft.; diameter, 9ft.; immersion, 1ft. 6in.; temperature, on deck, 53 deg.; engine-room, 84 deg.; stoke-hole, 90 deg.; weather barometer, 29·80 deg.

COST OF SHIPS.—An account has been issued showing the charges for works upon Her Majesty's ships in the financial year 1861-2. The sum of £613,829 was expended in building vessels in the dockyards, and £932,323 in building by contract or purchasing; also £368,292 upon ships commenced as wooden ships but converted into iron-cased vessels while building, and £118,480 upon ships launched as sailing ships, and subsequently converted into screw steamships. The sum of £1,033,048 was expended in fitting out or refitting steam vessels and in repairs and maintenance; also £183,395 in fitting out, refitting, repairing, and maintaining steam vessels permanently employed as troop, store, or surveying vessels, tenders, yachts, &c., and £63,898 for sailing vessels, £69,168 was laid out in the building and maintainance of yard craft, steam tugs, &c., and £9,642 in fitting and maintaining hulks. Details are given for each ship. The Accountant-General proposes to submit a further account for the same year, showing the cost of manufacturing and repairing articles of store in the several workshops and factories in the dockyards; and to supply before the close of the Session an account showing the value of the stock in hand in each dockyard on the 31st March, 1863.

THE AUSTRIAN IRON FLEET.—The Austrian iron-clad frigate, *Don Juan of Austria*, completely iron clad and equipped, left the Port of Trieste on the 16th ult. She goes afterwards to Pola to take on board her guns. There will thus be at Pola, in a very short time, the entire squadron of five iron-clad men of war, all ready for sea and active service.

NAVAL APPOINTMENTS.—The following appointments have taken place since our last. E. J. B. Bird, Chief Engineer, to the *Cumberland*, for the *Cadmus*; J. Grant, Acting Assist. Engineer, to the *Asia*, as supernumerary; R. S. Willcocks, Assist. Engineer, to the *Pandora*; J. L. Davies, of the *Sphynx*, promoted to Engineer; H. Williams, Chief Engineer, G. Lynch, Engineer, H. White, and J. Dingwall, Assist. Engineers, to the *Archer*; T. Baldwin, First-class Engineer, to the *Fisgard*, as supernumerary; W. P. Guyer, in the *Narcissus*, promoted to Acting Engineer; T. Waterlow, Chief Engineer, to the *St. George*; W. J. Ibbet. and C. F. Serjeant, Chief Engineers, to the *Pembroke* and *Urgent*, respectively; J. Roberts, Acting Chief Engineer, to the *Indus*, for the *Orontes*; T. Parker, Engineer, J. D. Lamont, and F. E. Shean, Assist. Engineers, to the *Jaseur*; J. Watt, of the *Hastings*, for the *Griper*; J. C. Williams, of the *Black Prince*, R. W. Jones, of the *Asia*, lent to the *Warrior*; L. Thompson, of the *Spider*, G. Thompson, of the *Fisgard*, T. Ball, of the *Leven*, and F. Wheeler, of the *Rattlesnake*, promoted to Engineers; S. Lawton, of the *Sparrow*, J. Pearse, of the *Malacca*, D. P. Steddy, of the *Immortalité*, N. Farrant, of the *Wrangler*, and G. H. Loxdale, of the *Topaze*, promoted to be Acting Engineers; R. Williamson, Chief Engineer, and J. Ross, Engineer, to the *Valorous*; J. Dyson, in the *Harrier*, promoted to Acting First-class Assist. Engineer; W. Russell and F. S. Turner, Assist. Engineers, to the *Valorous*; G. T. Stronach, Assist. Engineer, to the *Cumberland*, as supernumerary; T. Bullions, Chief Engineer, and J. Etherington, and W. Skelton, Assist. Engineers, to the *Hannibal*; W. Wotton, Chief Engineer, R. W. Hulford, Engineer, W. B. Cottam, J. Wendover, and G. Fordham, Assist. Engineers, to the *Leander*; C. F. Hulford, Assist. Engineer, to the *Cumberland*, for the *Arethusa*; J. Forster, Assist. Engineer, to the *Indus*, for the *Aurora*; R. W. Watson, in the *Petrel*, promoted to Acting Engineer; J. D. Lamont, Assist. Engineer to the *Cumberland*, as Supernumerary; W. Ball, Assist. Engineer, to the *Jaseur*; W. Fenton (a) and G. Edwards, Assist. Engineers, from the *Revenge* to the *Edgar*, for the *Trincolo*; R. J. Wemyss, Chief Engineer to the *Curaçoa*; F. Brockton, Engineer, to the *Fox*; R. T. Martell, Engineer, to the *Vigilant*; J. Rice, J. Slater, and G. Patterson, Assist. Engineers; and J. Merser, Acting Second-class Assist. Engineer, to the *Curaçoa*.

MILITARY ENGINEERING

EXPERIMENTS AT SHOEBURYNESS.—On the 27th March the members of the Ordnance Select Committeee and the Ironplate Committee, made some novel gunnery experiments at Shoeburyness, both with cannon and forms of projectiles. The first was made by the Ordnance Committee entirely, and consisted of trials to ascertain how far a method now rather in favour among French artillerists, by which a series of holes, about an inch in diameter, are bored through the substance of the cannon near its muzzle, in order, by permitting a quick escape of gas, to diminish its recoil, affects the service of the piece as to range and accuracy. The experiments were made with two brass nine-pounder ordinary smooth-bore field pieces, which were loaded with the usual service charges and spherical shot. Five rounds were fired from each gun in succession, the recoil of both being carefully measured after each discharge. They were then shifted, so that each occupied the platform which had been used by the other, when again more rounds were fired. The general merits of the performances of each gun could be seen at a glance, and were exactly what were anticipated before a shot was fired. The recoil of the ordinary gun was, in round numbers, just twice as great as that which had the holes bored round the muzzle, while the range and accuracy of the latter were scarcely more than half as good as that of the common piece. The lateral escape of gas and flame through the side holes of the French gun was very great indeed, so much so as to prove at once that even if the gun otherwise possessed the most transcendent merits it could never be used either on shipboard, in casemates, or even at embrasures. In the open air the trigger had to be pulled by a lanyard nearly 20 yards long. One half of the force of the explosion evidently escaped through the side holes before the force of the powder was expended on the shot, and virtually therefore the barrel of the gun is shortened by as much of its length as is thus perforated. The results obtained with this curiously bored gun on Friday were enough apparently to satisfy the Ordnance Committee that it would be a waste of time to continue the experiments further. Some experiments were then made with the Armstrong 110-pounder service-gun, loaded with steel shot, against a box target faced with 4½-inch plates, and lined inside with teak and an iron skin like the *Warrior*. The only interest of this experiment was to test the penetrative power of the projectiles, one of which was prepared by the Ordnance Committee, weighing 65lb. and fired with a 16lb. charge of powder. The immense superiority of this projectile over the cast iron and wrought iron shot, which, as the standards or units of penetration, were fired at the target before, was at once apparent. Its indentation was nearly 50 per cent. deeper than either the wrought or cast iron missiles. The next shots tried were those of a peculiar kind of steel made by Messrs. Makin and Sons, of Sheffield. This occasion was the third time that steel shots supplied by this firm have been tried at Shoeburyness, and always with the same result—that their metal, both for toughness and hardness, is superior to any other kind that has yet been experimented upon. A conical-headed shot of this kind, of which the cone was small and sharp, with a very full shoulder, weighing 65lb. and propelled by only 14lb. of powder, smashed its cone completely through the plate, damaging the backing and breaking a rib behind—the greatest result that has ever been obtained with so light a shot and so small a charge. It was evident that only the very full form of the shoulder beneath the cone (part of which was sheared off) prevented the whole going completely through the target. A second shot of the same kind, the same weight, and fired with the same charge, struck the upper plate of the target on an uninjured part, and about 12in. from its edge. It completely smashed away a piece about 15in. deep, by 18 or 20 wide, splintering and ripping up the backing behind. One piece of the plate, of considerable weight, was carried far behind the target where it fell with the shot itself. An examination of the latter showed a part of the cone broken off, but in other respects it was little injured, though the injury to the target was very formidable, in spite of the hard, rather than tough, character of its metal. The trial seemed to show that to pierce the plates almost as much depends upon the metal of the projectile as upon either the gun or charge of powder which fires it. Certainly, the result seemed quite to upset the notion that a flat-headed shot is essentially necessary to punch armour plates, and, on the other hand, to strengthen the belief that the best form for this purpose may, after all, and with proper metal, be found to be the conical form adopted by Sir William Armstrong.

AUSTRIAN GUN COTTON.—Take cotton yarn and twist it into strands of suitable size to answer the same purpose as grains in gunpowder. (The size of these strands can only be ascertained by experiments.) It is then steeped for a few minutes in nitric acid contained in a stoneware vessel, squeezed, and thoroughly washed by water, which is permitted to fall upon it from a pipe set at a height of several feet. After this it is squeezed, and dried in a room heated to 130 Fahr., when it is ready to be treated with a mixture of nitric acid of 1·52 specific gravity, and sulphuric of 1·14 specific gravity. These acids, in equal quantities, are mixed together in a glass or stoneware vessel, and allowed to stand for twenty-four hours, then the prepared yarn is immersed in it for forty-eight hours, with occasional stirring; the vessels being covered; then it is squeezed, washed for several hours in running water, and dried again. After this it is soaked for a short period in dilute silicate of potash, squeezed, washed again, dried, and is fit for use. This gun cotton is manufactured by M. Reny, of Vienna. It emits but little smoke, and is not subject, like common gun cotton, to explode by percussion.

STEEL FOR FIREARMS.—Captain Caron has been for some time addressing papers to the Academy of Sciences about his experiments on steel, effected at the Depôt des Poudres et Saltpêtres, for the pupose of applying that metal to ordnance and firearms in general. More than twelve months ago, samples of a peculiar soft steel were brought to the artillery factories, and the remarkable qualities of this metal induced Colonel Trielle de Beaulieu, the director, to apply it to the manufacture of tubes intended to protect the copper of the points of sight of heavy ordnance. This steel has the property of drawing cold, in tubes of any dimensions, and after drawing—above all, if the metal be tempered—the grain, perfectly homogeneous, is fine and watered, the steel has become strengthened (*nerveux*), and offers an extraordinary amount of resistance. Since then, gun barrels, manufactured from the same material, have been presented to the factory for the models of arms, and Captain Maldin, director of this establishment, struck by the beauty of this metal, thought it his duty to try the barrels, in order to establish their quality. The following are the very curious results at which this officer has arrived:—A gun barrel of the ordinary dimensions of that of a sporting gun, after having been trued, was tried first with 30 grammes (1 oz.) of powder, and one ball of 37 grammes (1¼ oz.) This charge, producing no deterioration, was followed by trials with a ball of the same size, and increasing the charge by 10 grammes at a time up to 60 grammes (2oz.) The 60 grammes were then replaced by 40 grammes of extra fine Esquerdes powder (the most destructive powder known). Not being able to burst the barrel, the experiments were continued with gunpowder, and after some trials, a charge of 150 grammes (5oz.) was arrived at without inducing a rupture. A last experiment was then tried, in which 150 grammes (5oz.) of powder and five balls were employed, the latter weighing together 135 grammes (say 4¾oz.) well rammed home The only injury seen was a swelling in the barrel at the spot where each of the balls were placed, but the barrel was not burst, not even cracked. If it be considered that the charge of powder was already 23in. long, and that a more considerable quantity would not have had time to burn entirely, it may be fearlessly concluded from these experiments that the metal employed in the manufacture of these barrels is capable of giving arms which cannot be burst by the effort of any charge of powder whatever.

THE ARMSTRONGS.—Admiralty instructions have been received at Chatham, directing that particular care is to be used in increasing the strength of all breeching bolts, in order to resist the enormous strain of the recoil of the Armstrong guns owing to their lightness as compared with the shot fired.

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STEAM SHIPPING.

The Peninsular and Oriental Company's Fleet.—Two of the eight new vessels by which the Peninsular and Oriental Company's already numerous and powerful steam flee: is about to be augmented—viz., the *Poonah* and the *Carnatic*—are now completed and ready for sea. The first of these had her official trial trip on the 11th ult. The *Rangoon*, built by Messrs. Samuda, has recently been launched; the *Syria*, building by Messrs. Day and Co., of the Northam Ironworks, at Southampton, will be ready about September next; the *Golconda*, by the Thames Ironworks Company, at the end of the year; the *Delhi*, by Messrs. Wigram, in the spring of 1864; the *Baroda*, by Messrs. Samuda, in the summer of 1864; and orders have just been given to the Thames Iron Company to construct a new paddle steamer which is not yet named. All these vessels are screws, with the exception of the *Syria* and the one last mentioned. The *Poonah* is a magnificent screw steamer, built and equipped by the Thames Ironworks Company at Blackwall, and fitted with engines of 500-horse power nominal by Messrs. Humphrys and Tennant, of Deptford. The length of the *Poonah* is 315ft.; extreme breadth, 41ft.; depth of hold, 30ft.; tonnage, builders' measurement, 2596; 3370 tons displacement. She has 609ft. of section and 226ft. of firebar; and her indicated horse-power is 2356. She has a pair of compound engines, on the same principle as those of the *Mooltan*, but laid horizontally instead of vertically, as in that vessel, and at a moment's glance will convince the most unpractised eye that engines of this character are well adapted for ships of war, they being out of the way of all shot. The vessel is steered by Mr. Humphrys's hydraulic steering gear, which has been found to answer so well in the *Mooltan*, and among other numerous ingenious inventions she is fitted with Captain Field's improved compass corrector and course register. The following is the result of four runs at the measured mile in Stokes Bay.—First run, 4 minutes 4 seconds, equal to 14·754 knots per hour, 64 revolutions; second run, 4 minutes 52 seconds, equal to 12·329 knots, 64 revolutions; third run, 4 minutes 11 seconds, equal to 14·342 knots, 61 revolutions: fourth run, 4 minutes 51 seconds, equal to 12·371 knots, 63 revolutions; the true mean of the whole being 13·391 knots per hour. Pressure of steam, 25lb.; vacuum, 25; weight of coals, water, &c., on board, 893 tons. She ran on an even keel, the draught of water being 19ft. 11in., both fore and aft. When at full speed the ship made a full turn in 8 minutes. The machinery worked in the freest manner throughout the trial.

The Trial Trip of the "Princess Alexandra" took place on the 8th ultimo. The *Princess Alexandra* has lines well adapted for sea-going qualities. Her length between perpendiculars is 176ft.; breadth, extreme, 24ft.; depth, 14ft. 7in. She has a pair of engines by Messrs. Penn and Son, each of 90 horse-power, but capable of working up to six times that power. The engines are upon the oscillating system, the cylinders of 52in., stroke 4ft. At the measured mile off the Lower Hope, the distance was run against tide in 4 min. 45 sec., giving a speed equal to 12·63 knots per hour. On returning with the tide, but against a strong head wind from S.W., the measured mile was run in 3 min. 46 sec., equal to a speed of 15·9 knots per hour. The mean of the run was at the rate of 14·26, being nearly 1½ knots above the contract speed.

Trial of the New Steamer "Carnatic."—This handsome vessel was built on the Thames, by Messrs. Samuda, and engined by Messrs. Humphrys and Tennant, of Deptford. Her keel was laid on the 30th of January, 1862, and she was launched on the 6th December last. The following are her dimensions:—Length over all, 315ft.; length between perpendiculars, 285ft.; extreme breadth, 39ft.; depth of hold, 28ft.; tonnage, builders' measurement, 2014; displacement, 2800 tons; midship section immersed, 548ft. She is fitted with a pair of combined cylinder engines, inverted, with surface condensers, two of the four cylinders being 43in. diameter and the other two 96in., with 3ft. stroke, and Lamb's patent sheet flue boilers. She is propelled by a two-bladed screw, with the leading corners cut off, diameter 16ft., and 23ft. pitch; and steered by Humphry's patent hydraulic steering gear. The weight of coals, water, stores, and ballast on board during the trial on the 18th ult. was 793 tons, and the vessel's draught of water was 18ft. 5in. forward, and 18ft. 4½in. aft. The *Carnatic* made four runs at the measured mile in Stokes Bay with the following results:—1st run, 5m. 9s., equal to 11·650 knots per hour, 71¼ revolutions; 2nd run, 3m. 54s., equal to 15·384 knots, 71 revolutions; 3rd run, 4m. 47s., equal to 12·543 knots, 72 revolutions; 4th run, 3m. 50s., equal to 15·652 knots, 72¼ revolutions; pressure of steam, 26lb.; vacuum, 28; force of wind, 4, E.N.E. to S.S.E. The true mean of the four runs was 13·885 knots per hour. The first and third were against wind and tide, and the second and fourth with. The engines, which are of 400-horse power nominal, indicated 2442 during the trial, being over six times; whilst four times the nominal horse-power is generally considered good for a new vessel. She has 168ft. of firebar, so that the result showed no less than 14-horse power per foot of firebar; whilst Her Majesty's ship *Warrior*, on her trial trip, realized 6½-horse power per foot of bar, the difference being the true measure of the economy of fuel.

Trial Trip of the Steamer "Roman."—The new screw steamship *Roman*, one of the fleet of the Union Company, which carries on the mail service between this country and the Cape of Good Hope, underwent an official trial on the 23rd ult., at the measured mile in Stokes Bay, prior to leaving with the outward May mails. This vessel, which is the seventh built for the company by Mr. Charles Lungley, of Deptford-green Dockyard, is the second he has constructed on his unsinkable and fireproof principle. A watertight trunkway is carried from each lower deck to the upper deck, so that in the event of water getting into either of the bulkheads it cannot rise throughout from deck to deck, as in ordinary ships, but can only rise in the watertight trunkway, the rest of the vessel being kept buoyant and free from water. The dimensions of the *Roman* are as follows;—length over all, 279ft. 10in.; length between perpendiculars, 269ft.; breath of beam, 32ft. 3in.; depth of hold, 26ft.; registered tounage, 1027 tons. The engines, constructed by Messrs. Day and Co., of the Northam Ironworks at Southampton, and laid horizontally, are of 220 nominal horse power, giving out an indicated power of 973, and are fitted with the modern improvements for saving fuel,—viz.. superheating apparatus, surface condensers, and steam jackets to the cylinders. The results of four runs at the mile were as follows': 1st run, 5 min. 4 sec.. equal to 11·841 knots per hour, 74 revolutions; 2nd run, 5 min. 8 sec., equal to 11·688 knots, 72 revolutions; 3rd run, 5 min. 26 sec., equal to 11·043 knots, 75¼ revolutions; 4th run, 4 min. 44 sec., equal to 12·676 knots. 75½ revolutions; pressure of steam, 22½lbs.; vacuum, 26in. The true mean of the four runs was 11·588 knots, to which the surveyors add a third of a knot to compensate for the adverse influences of the wind, which was blowing strong throughout from the north-west, with a force of 5 to 7. The vessel's draught of water was 14ft. 5in. forward, and 15ft. aft., and she had 470 tons of coals and stores on board. The *Saxon*, a sister ship to the *Roman*, and which is now making her maiden voyage out to the Cape, was built and engined by Messrs. Day and Co., the engines for the *Roman* being the ninth pair constructed by that firm for the Union Company. This Company has the longest steam line in existence, and as an instance of the test to which the machinery of these Cape steamers is subjected, it may be mentioned that on her last voyage the *Briton* made the run from Plymouth to Table Bay in 32 days 19 hours, during which time her engines were not once stopped, and thus made by the counter 2,644,320 revolutions without cessation.

Iron Shipbuilding on the Diagonal Principle.—An iron clipper ship, called the *Sydney Eggers*, and built on Taylerson's patented diagonal principle, is at present to be seen in the Wapping Dock, Liverpool. The principle adopted by Mr. Taylerson, and for which he has obtained a patent, is widely different from that now employed by shipbuilders. In the ordinary construction the frames are placed vertically, and parallel to each other, the frames being secured to the outside skin by rivets in a direct vertical line from the gunwale to the keel on each side of the vessel. This plan, Mr. Taylerson contends, is a source of weakness, springing from two causes—first, the frames, being in a vertical direction and parallel to each other, cannot offer sufficient resistance to any force or strain having a tendency to tear the ship asunder; and, secondly, the frames being secured to the outside shell by rivets running in a vertical line from the gunwale to the keel entail one continuous line of weakness in that direction. The leading features of the diagonal plan, as described by the inventor, are these:—"That in the case of the vertical principle the line of resistance to any force acting in the direction of the vertical planes of the ship will be in a line with the shortest circumferential line of the body of the ship, thereby opposing the least amount of resistance to fracture coming in the direction of these planes; whereas, in the case of a ship built in accordance with my diagonal principle the line of resistance to forces acting in the direction of these vertical planes be diagonal to the circumferential line of the body of the ship, thereby opposing the greatest amount of resistance that can be given to an angle equivalent to the inclination of the frames. The same argument and the same reasoning apply to the perforations in the plates, or outside skin, which, running in the same vertical line with the frames, as already described, produce a series of lines of inherent weakness in the structure of the ship, and which I propose to remedy by my patented mode of making the line of junction of the butts of the plates diagonal instead of vertical, as in the present mode of construction." In connection with the diagonal framework Mr. Taylerson's introduces bulkheads on a new construction, and also a hollow keel and keelson, all of which afford increased strength and security to the vessel. The ship *Sydney Eggers* affords an illustration of the patent. She is a handsome vessel, of 847 tons register, with extensive carrying capacity. In a report from Mr. R. Thornton, civil and practical engineer, Edinburgh, he states that to tear assunder a ship on the vertical principle, size and weight of metal being the same as Taylerson's, a strain would be required equal to 11,610 tons weight at each end; whereas on the diagonal plan it would bear a strain equal to a weight of 23,152½ tons without any injurious effect on the vessel.

LAUNCHES OF STEAMERS.

Launch of the "Marco Polo" Mail Steamer.—On the 9th ult. Messrs. W. Simons and Co., London Works, Renfrew, launched a very handsome new passenger paddle-steamer for the mail service of 750 tons, and 250 horse-power. She was christened *Marco Polo* by J. Beaumont Neilson, Esq. The engines were also manufactured at the London Works, and were started and worked on board.

Launch of Steamers on the Clyde.—The Clyde builders continue exceedingly well employed. Messrs. Henderson, Coulburn, and Co., of Renfrew, have launched a screw named the *William de la Rue*, 177ft. in length, 24ft. 6in. in breadth, and 13ft. in depth, with engines of 90-horse power on the diagonal oscillating principle. She has been built for Mr. H. S. Seligmann, of Glasgow, and is to be devoted to the Bordeaux trade; her builders are now engaged on a sister vessel for the same line, which is nearly ready for launching. Messrs. W. Denny and Brothers have launched a screw of 2000 tons, built for Messrs. A. Lopez and Co., of Alicante, and intended for the Spanish line of mail steamers between Cadiz and Havannah. She has been named the *Principe Alfonso*, and is now being fitted by Messrs. Denny and Co. with engines of 400-horse power.

TELEGRAPHIC ENGINEERING.

Submarine Cable in Lough Foyle.—Mr. B. D. Watlock, chief engineer of the Magnetic Telegraph Company, lately submerged a telegraph cable in Lough Foyle, by means of which from two to four hours will be saved in the transmission of despatches by the Canadian steamers.

Submarine Telegraph Communication—Duncan's Ratan Cable.—The strength of this cable has been carefully tested, and given satisfactory results. A copper wire of seven strands, the combination being about ¼in. in diameter, is surrounded with a protecting covering of India rubber, or other suitable material, and the canes are then laid spirally round, as in the ordinary wire-rope cable. It has been found by experiment that a cable so made, and protected with a coating of Duncan's patent compound, weighs but ¾ ton to the nautical mile, and will bear a breaking strain of 2½ to 2¾ tons, the specific gravity being 1·059. When a single wire is laid with each cane, so as to give additional weight and strength, the weight is raised to 1 ton per nautical mile, and the breaking strain is 4 tons, the specific gravity being 1·288. And when by laying a double wire with each cane the weight is raised to 1¼ ton per mile, the breaking strain is from 6 to 6½ tons and the specific gravity 1·54. Mr. Duncan states that in the last two instances floatation and gravitation are excellently and mechanically united and balanced. With regard to the joining of the canes, he tells us that some doubts have been expressed as to the practicability of effectually and strongly joining the canes, he is desirous of stating that the joints are made very easily and simply, and on being tested they have been proved to be as strong, or even stronger, that the canes themselves. The joints will be arranged to fall at intervals and break joint, so as to secure the maximum strength. It is considered that although ratan cane is most peculiarly and strikingly adapted for deep water cables, yet by its wonderful durability in foul mud, and other usually destructive influences, it is not less valuable as a protection to the heavy metal sheathing of shallow water cables.

Extracts from Dr. Odling's Report on ratan cane.

"The entire cane yields 8·03 per cent. of ash, having the following composition:—

Silica	76·04	Soda	6·86
Sulphuric acid	7·36	Lime	2·37
Potash	7·30		
Total			90·93

with traces of iron, manganese, magnesia, and phosphoric acid. The outer portion of the cane, sliced off with a knife, yields 40·04 per cent. of ash, of which 97·07 per cent. is silica. The remainder of the cane, from which the exterior had been sliced off, yields 2·40 per cent. of ash, of which 28·26 per cent. is silica. The substance of the cane is made up of cellular tissue, with irregularly interspersed bundles of woody fibre, or more correctly, of fibro-vascular tissue. The cuticle of the cane consists of flattened closely adherent cells, filled with silica, so as to form a complete siliceous sheath to the whole."

RAILWAYS.

The East India Railway, which was begun in 1851, has been carried on at the rate of 90 miles a year, and is completed from Calcutta to a point near Delhi, with the exception of 140 miles.

Railway through Greenwich Park.—Two reports, one by Prof. Airey, the other by Admiral Washington, on the above line of railway, which has lately been proposed, have been just published. Admiral Washington says:—"I have read the report of the Astronomer Royal, giving the result of some former experiments on the vibration caused by the passage of a railway train at the distance of 1000ft., and I am of opinion that their lordships should withhold their assent to any line of railway that passes within that distance of the Royal Observatory. No doubt the accommodation and convenience of the travelling public should have every consideration, but with all due deference it must not be allowed to interfere with the high character that the astronomical observations made at Greenwich have hitherto borne. Of the two proposed railways the London, Chatham, and Dover extension passes within 825ft., and the South London, Greenwich, and Woolwich within 610ft. of the Royal Observatory. I therefore submit that their lordships refuse their assent to both the above bills, and that the Board of Trade be so informed."

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METROPOLITAN RAILWAY COMMUNICATION.—The Select Committee appointed to inquire whether any, and, if any, which of the schemes before Parliament for the construction of lines of railway within the limits of the metropolis can be proceeded with in the present session without the risk of interfering with the future adoption of a comprehensive plan of metropolitan railway communication, and to consider what provision can be made for the securing such a comprehensive system, with the greatest advantage to the public, and the least inconvenience to the local arrangements of the metropolis, and to report to the House,—report that the committee have met, and having considered the Bills referred to them according to the terms of the reference, but without any consideration of their merits, they are of opinion that there is no reason why the following Bills should not be proceeded with in the ordinary course.—The Midland Railway (Extension to London) Bill; Barnes, Hammersmith, and Kensington Railway Bill (the agent for the Bill having informed the committee that it is not intended to proceed with that portion of the line between Kensington and the junction with the West London Extension Railway); Hammersmith and City Railway Bill; Victoria Station and Pimlico Railway Bill; Tottenham and Hampstead Junction Railway Bill; London, Chatham, and Dover Railway (No. 1) Bill (with the exception of the Thames Branch); Ludgate Station and Junction Railways Bill; and London, Brighton, and South Coast Railway (Extensions and Alterations, &c.) Bill And the committee are also of opinion that it is not expedient to proceed further with the East London and Rotherhithe Railway Bill; Grand Surrey and Commercial Docks Railways Bill; Metropolitan, Tottenham, and Hampstead Railway Bill; Rotherhithe Railway Bill; and the London Railway (Victoria Section) Bill.

THE LUDGATE HILL VIADUCT.—The secretary of the London, Chatham, and Dover Railway states that the company are willing to construct such a bridge as will, at once, be an ornament to the City, and at the same time facilitate the widening of Fleet-street, so that from the foot of Ludgate-hill, where the bridge crosses, a good view of St. Paul's may be obtained.

THE RAILWAY FROM ROME TO CIVITA VECCHIA.—An accident of a single nature threatens the railway from Rome to Civita Vecchia. It consists of a subterranean flame, a sort of incipient volcano, which has shown itself at the place called Mont-des-Pictres, seven kilometres from Rome. The focus of the flame is on the slope on the right hand side of the railway, in going from Rome to Civita Vecchia. The space occupied by the crevices which give forth the sulphurous exhalations is about 20 metres in length by 10 in width. The temperature of the surface of the soil is remarkably high, so that at certain points it is painful to remain standing for a few moments, even with strong shoes. In penetrating the soil to the depth of a metre, the rock is found to be incandescent, and visibly red in open day. This ignited rock is a clayey slate, rich in lignite and in fossil vegetable deposits reduced to a bituminous state.

THE MONT CENIS TUNNEL.—Mr. Bartlett, an English engineer, set to work a boring machine, by which a tunnel could be pierced with a rapidity eight or ten times greater than any hitherto obtained by ordinary means; but Mr. Bartlett's contrivance was wrought by steam, and could not be applied to a tunnel where air could not be had for combustion. The Italian engineers proposed to substitute compressed air instead of steam; and, notwithstanding long opposition on the part of foreign scientific men, their method is now in full operation, and their success exceeded the most sanguine expectations. The tunnel was begun in 1857, with ordinary means. That year and the two following were spent in preliminary operations, such as the construction of houses, workshops, &c., for in that inhospitable regions there was all to be done. The first experiments with the boring machines were made in 1861 at Bardonnéche, on the Italian side; but even on this side the regular work only proceeded uninterruptedly in 1862. The invention of the new machine was yet in its infancy; its occasional failures, and even its gradual improvements, could not fail to cause considerable delays. The tunnel at Bardonnéche, on Jan. 1, 1863, was 1274 metres. In the years 1857, 8, 9, and 1860, 724 metres had been achieved by ordinary means. By the aid of the new machines 170 metres were added in 1861, and 380 in 1862. On the Savoy side, at Modane, from 1858 to Jan. 1, 1863, only the ordinary means were employed, and the result was for the whole of that period only 925 metres. The tunnel, calculating the work achieved at both ends up to the beginning of the present year, has attained a length of 2199 metres, 550 of which have been made with the new machines. What was done at Bardonnéche in 1862, in spite of the imperfection of a half-developed method—namely, 380 metres—must surely be possible in 1863; nay, it is quite certain that the result of the present year will be at least 400 metres. On the side of Modane, again, the new method was applied on Jan. 25 last, and, as there the errors which retarded the work at Bardonnéche will be avoided, the avoided, the result of the work on both sides for 1863 will be no less than 800 metres. The engineers are very confident that the work will proceed with even greater speed, but the Minister would base his calculation on the most certain data, and, by limiting the results of the yearly progress to 800 metres, he thought the whole undertaking would be achieved in 12½ years.

RUSSIAN RAILWAY.—The concession for a railway from Kieff to Odessa has been granted by the Government to a Russian company. The railway will be 647 verats or 429 miles long, with two branches of 300 versts or nearly 200 miles each. The capital will amount to 55,000,000 roubles, or £8,500,000, under a government guarantee of 5 per cent. interest.

RAILWAY ACCIDENTS.

ACCIDENT TO AN EXPRESS TRAIN ON THE GREAT NORTHERN RAILWAY.—An express train on the Great Northern Railway, travelling at the ordinary speed of 40 miles an hour, was nearly dashed to pieces on the evening of the 4th ult., but fortunately no lives were lost, although, most of the passengers were severely hurt. The accident happened close to the Little Bytham station, about seven miles from Stamford. For some distance north of Little Bytham the line runs along a high embankment, which on passing the village itself is elevated above the tops of the adjacent houses. Some 50 yards from the station are a series of what are called "coal drops," by means of which coal trains are unloaded of their contents; the coals passing through openings between the rails to the ground below, whence they are carted away. At this point the line appears to be elevated somewhere about 20ft. above the road below. On a siding over the coal drops stood a number of goods van and cattle trucks at the time of the accident, and to this circumstance must in a great measure be attributed the escape of any of the passengers with their lives. An express train leaves Manchester for London at 3 p.m., and on this occasion consisted of four composite carriages, separated from the tender by a break-van; the rear being brought up by a second break-van, in which was the guard. At 6 o'clock the train had just passed Little Bytham village, and was within about 150 yards of the station, the speed being, as already mentioned, at least 40 miles an hour, when the tire of the leading wheel of the engine suddenly snapped and flew off. The whole train immediately left the main line, ploughed up the ballast, and rushed through the metals of several sidings. The engine struck the first of the vans standing over the coal drops before mentioned. Most of the cattle trucks and goods vans on the siding were completely shivered to fragments, the woodwork being detached from the wheels and strewn all around; strong telegraph poles were snapped like slender reeds, and to add to the confusion the wires rendered temporarily useless for communication; the engine and tender were doubled up in a way which plainly indicates the terrible force of the collision, while the carriages of the train were shattered and piled about the embankment in a state of ruin which rendered it apparently hopeless to expect that any of the passengers could be found alive. One of the carriages, containing several persons, occupied a most extraordinary position; the wheels at one end were resting across the metals on the verge of the embankment, while the other end was supported by the telegraph wires, and thus prevented from falling a considerable depth.

ACCIDENT TO AN EXPRESS TRAIN.—On the 21st ult. the express on the Great Western line which left Birmingham for Birkenhead at 8.55 suddenly broke down on the Bradley embankment. The train was running at about 30 miles an hour, had not stopped since leaving Birmingham, and had above three miles to run before it would reach its first stopping station at the entrance to Wolverhampton. When the train was nearing the Bradley-bridge the engineer was alarmed by a violent jerk among the machinery of the engine, which immediately afterwards began, in the words of the engineer to "roll about very much," but it did not leave the metals, and was brought to in about 300 yards. It was then found that the massive crank axle of the engine had broken at the big end journal of the connecting rod, where it is about 11 inches across, and about 4 inches in thickness. The driving-wheel at this end of the axle thus becoming liberated, it fell between the flange of the rail and the timber and broke off a part of the splasher, and to this extent happily the accident was confined. There were about six carriages in the train, with the ordinary complement of passengers, who escaped all injury. The train which was dated out of Birmingham five minutes after the express left was kept back by the prompt action of the officials in charge of the train, who hastened to Wednesbury and had the usual signals put up, after themselves placing the fog signals upon the rails.

BOILER EXPLOSIONS.

MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.—At the ordinary monthly meeting of this Association, held the 31st March, the Chief Engineer presented his monthly Report, of which the following is an abstract:—"During the past month, there have been examined 370 engines—1 specially; 492 boilers—6 specially, 17 internally, 60 thoroughly, and 409 externally, in which the following defects have been found:—Fracture, 2 (1 dangerous); corrosion, 18 (2 dangerous); safety valves out of order, 4; water gauges ditto, 24; (1 dangerous); pressure gauges ditto, 16; feed apparatus ditto, 5; blow-off cocks ditto, 47 (1 dangerous); over-pressure, 2; deficiency of water, 2; blistered plates, 2. Total, 130 (6 dangerous). Boilers without glass water gauges, 1; without pressure gauges, 1; without blow-off cocks, 36; without back pressure valves, 58. Two explosions have occurred during the past month to boilers not under the inspection of this Association, by which 15 persons were killed, and 16 others injured, making a total of 31. Both boilers have been personally examined subsequent to the explosion. No. 4 explosion occurred at an ironworks to a boiler connected to a series of eighteen others. It was very similar in general construction, though not precisely so, to those known as upright furnace boilers, like which, it stood erect, was of considerable height, and surrounded with brickwork. The top of the boiler was hemispherical, and the bottom flat; whereas, in the ordinary furnace class, both ends are hemispherical, which is an important difference. The boiler was 20ft. high, and about 9ft. 6in. diameter. The internal fire-box was 10ft. high, 4ft. 6in. diameter at the crown, and also for about the first 3ft. 6in. below; from which point it tapered outwards to a diameter, at the bottom, of 6ft. 6in., leaving an annular water space all round, about 18in. in width. between it and the shell. This fire-box was united to the shell at the bottom, by a flat plate connected by rings of angle iron inside the water space. The crown of this internal fire-box was slightly domed, and flanged at its attachment to the cylindrical sides, being amply stiffened by six angle irons laid across and well rivetted to it. At the upper part of the fire-box were the two outlets previously referred to, and which were formed by short transverse flues passing through the water space, and thus establishing a communication between the internal furnace and the external flue. These short flues, which were opposite one to the other, and at right angles to the furnace door, were 2ft. 6in. in diameter, and attached by rings of angle iron at each end. The thickness of the plates was: in the hemispherical end and cylindrical sides of the external shell, three-eighths of an inch; in the flat plate at the bottom of the water space, seven-sixteenths; while all the angle irons were 3in. by 3½in. thick. In the fire-box, the thickness of the crown plate was half an inch, and that of the sides seven-sixteenths. With regard to the lay of the plates, that in the shell was according to the usual plan, being radial in the hemispherical end, and circumferential in the cylindrical sides, the seams in the latter breaking joint; while, in the taper-portion of the fire-box, the plates were laid longitudinally, and thus, which it is important to notice, the seams were in line for a length of between six and seven feet. The riveting was single throughout, and the seams were the ordinary overlap. The boiler had been fitted with a float, two gauge laps, one feed stop-valve, one feed back-pressure valve, and one lever safety-valve of 5in. diameter, which was loaded to a pressure of nearly 50lb., and at all events would have allowed the steam to have reached that pressure when blowing off freely. Also there were two junction valves, one of which was in the steam-pipe communicating with the entire series of boilers, and the other in that connected to the steam-hammer. There was no steam pressure-gauge on the boiler itself, but one was fixed to the main steam-pipe beyond the junction valve, and thus afforded no indication of the pressure of the steam within the boiler, when it was shut off from the others in the series. Both of the junction valves were closed at the time of the explosion, and thus the safety-valve formed the only outlet for the steam. What the pressure then rose to cannot now be ascertained, the steam-pressure gauge, as just pointed out, giving no indication under such circumstances. The safety-valve, however, was found to be free after the explosion, and there is no reason to conclude that it had been otherwise previously. But it is apparent, from this, how circumstances will arise which make it important that every boiler should be fitted with a duplicate safety-valve, as well as with its own independent pressure guage. A serious oversight had been made in the design of the boiler, the top end being hemispherical and the bottom flat. The hemispherical end would, when the steam was fully up and blowing off freely, have an upward pressure of nearly 250 tons acting upon it and tending to tear it away from the bottom. There would be an equal downward strain counteracting this, induced by the pressure of the steam upon the crown and tapering sides of the fire-box, combined with that upon the flat plate forming the bottom of the annular water space. As long as the attachment between the bottom and the top of the boiler held good, the two forces would be held in equilibrio, and the boiler remain at rest upon its bed. But should the attachment fail, the upward force would instantly shoot the top of the boiler up into the air with a buoyancy of 250 tons, which, it may be remarked, is equal to the weight of a long railway train, including the engine and tender fully equipped with coke and water. This action is exactly what took place. The flat plate at the bottom gave way, rending completely round through the seam of rivets, at the outside ring of angle iron which attached it to the shell; when the boiler flew up and was carried to a distance of 160 yards from its original seat. The brickwork at the top of the chimney was shaken, and there were marks of violence on the crown of the boiler, so that it is possible that it struck the top of the chimney in its course. There is nothing surprising in this, when the amount of the pent-up force of steam within so large a boiler is considered, and the due appreciation of which shows how unnecessary is the supposition of the existence of explosive gaseous compounds, or any force greater than that of the steam itself; while the propagation of such theories only tends to divert attention from the real cause of steam boiler explosions. The rent at the flat bottom plate, however, was by no means the only one that was made. The short transverse flues passing through the water space, and which considerably assisted the bottom plate, also gave way, and were torn from both the shell and fire-box, their mode of fracture giving unmistakeable evidence of the upward flight of the shell. The resistance of these flues to fracture had severed the fire-box in the waist at the ring seam of rivets, at which the longitudinal plating terminated; and thus the fire-box crown, as well as one ring of plates with the two short flue tubes, had flown up together with the shell, which made a somewhat remarkable and complicated feature in the development of the rents. Added to this, the remaining portion of the fire-box, which was taper, and plated longitudinally, rent at one of the longitudinal seams opposite the fire door, and collapsed at that part. No. 5 explosion occurred to one of two mill boilers working side

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by side and connected together, both being of the plain double fined, internally fired class, termed "Lancashire." The length of the one in question was 28ft., the diameter of the shell 10ft., and that of the flues, which were parallel throughout their whole length, 3ft. 9in., the thickness of the plates was seven-sixteenths in the shell, and three-eighths n the flues. The boiler had been fitted with one glass-water gauge, one feed back-pressure and stop-valve combined, one blow-out tap, one lever safety-valve, and one Schæffer steam pressure-gauge, common to both boilers. The pressure at which the safety-valve was stated by the engine attendant to have blown off, was 30lb. on the square inch, which an examination of its dimensions, levers, and weights corroborated. On examining the boiler it was found that the right hand flue had collapsed from one end to the other, and by the flattening action had become severed completely in two at some of the ring seams of rivets, as well as torn away from the end plate at the back of the boiler. The boiler had not stirred from its original position, and the connections to the one alongside remained unbroken. The rush of water, however, from the opening at the back, had blown up the brick flue and carried away the end wall of the boiler house, in consequence of which a floor above, as well as some cast-iron girders by which it had been supported, were brought down. It was by the fall of the building that the three men received their injuries, one of whom was found to be dead when dug out of the *débris*. At the front end of the boiler the furnace mountings had been blown off. With regard to the cause of the collapse, there was no evidence of "shortness of water," judging from the appearance of the plates; added to which, the other furnace in the same boiler remained unaltered in shape, which could not have been the case had deficiency of water occurred; while, in addition, it appeared that the collapse of the flue had commenced at the middle of its length, and not over the furnace, where the shape was less distorted than at any other part. The collapse cannot be fairly attributed to "shortness of water," but its true cause will be found in the construction of the flue, which was not strengthened with flanged seams or the addition of any hoops. Such a flue as the present, of so large a diameter at 3ft. 9in., and 28ft. long, made of plate only three-eighths thick, is not safe for regular work with steam at a pressure of 30lb. per square inch, as was the case in this instance, It might work for a time, but still there would be a risk, as the event proves; a rise that might have been avoided had the flue been strengthened with any of the approved methods, namely, flanged seams, or hoops, either of angle-iron, T iron, bridge rail section, or any other suitable form; to the importance of adopting which attention has been called, it is feared with tedious frequency, though an apology for so doing, it is thought, may be found in the frequent occurrence of such explosions as the present, and in the loss of life consequent upon them. It may here be added, there is every reason to conclude that the boiler in question was an illustration of the danger referred to in previous reports, arising from internal flues being actually oval, although supposed to be circular. The angle iron rings at the end plates were circular, but the inclination of the axis of the collapse of the flue indicated that the middle portion had been oval. The other flue alongside was evidently so, and had, in consequence, been strengthened by two stays attached to the crown. The flues of all the boilers under inspection of the Association are guaged to ascertain their actual shape, when the members allow an opportunity of making "thorough examinations," without which it cannot be done; and very numerous are the instances in which flues, previously supposed to be circular, are found on actual measurement to be oval.

Boiler Explosion near Glasgow.—At an early hour on the 9th ult. a boiler explosion, resulting in serious loss of life, occurred at the Mossend Ironworks, near Holytown, a station on the Caledonian Railway, about 13 miles from Glasgow. The works in question, which are the property of the Mossend Iron Company, cover nine or ten acres of ground, and comprise several large sheds occupied by forges, together with an extensive rolling mill. The machinery in these two departments was driven by separate engines, these again having each its own set of boilers, and it was to the boilers connected withthe rolling mill that the accident occurred. These boilers were five in number, and were placed side by side on a solid foundation of brick, their ends pointing towards the north and south. They were all 25ft. in length, and four of them, which were egg-end boilers, were 5ft. in diameter, while the fifth, a flue-boiler, had a width of 6ft. The fire-hole extended along the south ends of the boilers. Beyond this is a tramway, on which some coal-laden trucks were standing at the time of the accident, and south of this again stands the rolling mill. On the west side of the boilers, at a distance of about 20 yards, are the forges, and on the east side, about double the distance off, is an engineer's shop. The chimney which carried off the smoke from the furnaces stands on the north-west corner of the square site which the boilers occupied. At the time when the accident occurred—2 o'clock in the morning—there were upwards of 300 men engaged in the works, the greater portion of them being dispersed through the forges and rolling mill in the immediate neighbourhood of the boilers. At the hour mentioned the whole neighbourhood was alarmed by a crash, followed by a shower of bricks and other débris, which flew in all directions to a distance of 300 or 400 yards. On repairing to the spot, it was found that the site formerly occupied by the boilers presented a yawning crater, the force of the explosion having completely torn up and scattered to a distance the mass of substantial brickwork. As for the boilers, one with both ends blown out lay along the tramway to the south of the firehole, where it had thrown down the chimneys of two of the rolling mill furnaces; the greater part of another lay a little further to the south, among the ruins of the rolling mill sheds; a third had been precipitated about 30 yards to the northward of its bed, where it lay in the shape of a huge spiral riband; while the remaining two had been hurled northwards quite out of the works, and alighted in a field at a distance of about 250 yards. Besides these ponderous masses, domes, ends, and other fragments of boilers had been thrown to great distances both to the north and south. One large piece, weighing about two tons, had flown across the turnpike road on the south side of the works and alighted in a field at 330 yards' distance. The roofs of the rolling mill sheds were completely destroyed by the falling débris, and those of the forge sheds and the engineer's shops suffered considerably. Of the persons employed in the neighbourhood of the boilers seven were either killed on the spot, or so severely injured that they did not long survive the accident; while several others were more or less hurt.

WATER SUPPLY.

Water Supply of Paris.—Among the numerous advantages bestowed on the inhabitants of Paris within the last few years is to be reckoned a good supply of pure water. Paris now receives, from various sources, a volume of water equal to 153,000 cubic mètres daily, of which the canal of the Ourcq supplies 105,000 cubic metres. This water is distributed by means of 20,948 mètres of pipes for the supply of houses, and of 754,852 mètres of pipes for the supply of the public, of which the diameter of the largest is not less than one mètre ten centimètres. Two steam pumps are being constructed on the Quai d'Austerlitz, of 100-horse power each, which will increase the present supply of water by from 12,000 to 15,000 cubic mètres the day. Taking the present daily supply of 153,000 cubic mètres, this is equal to 33,660,000 gallons, equal to about 20 gallons per head of the present population of Paris within the fortifications.

GAS SUPPLY.

Gas in Paris.—The annual meeting of the Paris Company for lighting and heating by gas has recently been held. The dividend declared was at the rate of 17 per cent. per annum, the profits realised in 1862 having been £1,200,000.

The Sheffield United Gas Light Company announces a reduction in their price of gas from 3*s.* 9*d.* to 3*s.* 6*d.* per 1000 feet—a reduction which also involves the payment of a dividend of 10 instead of 8 per cent.

The Gas Committee of Wolverhampton have presented a report to the Town Council, in which the following is found. "The Company charge the Corporation with a consumption of 18,000 cubic feet of gas for each annual lamp. This calculation is made on the basis of the original contract to supply five cubic feet per hour for 3600 hours. For the lamps which are burned only eight months in the year 14,000 cubic feet of gas is charged for 2800 hours." A reference to the following towns will show that the charges paid for lighting the lamps are considerably less than Wolverhampton, for while there the price is £3 12*s.* 6*d.*, it is in Ashton-under-Lyne, £1 4*s.* 1*d.*; Bath, £3; Birmingham, £3 10*s.*; Blackburn, £2 2*s.* 9*d.*; Bolton, £1 8*s.* 3*d.*; Bradford, £2 8*s.*; Bury, £1 8*s.* 2*d.*; Coventry, £2 10*s.*; Derby, £2 6*s.* 2*d.*; Preston, £2 16*s.* 7*d.*; Salford, £2 2*d.*; Dudley, £3; Leeds, £2 5*s.*; Manchester, £1 5*s.*; Sunderland, £2 15*s.* 6*d.*; Warrington, £2 14*s.*

CANALS.

Indian Canals.—The Indian Government has sanctioned the excavation of a canal through the Richia Doab, with its head near Aknoor, or at the confluence of the Chenab and the Tavoy.

DOCKS, HARBOURS, BRIDGES, &c.

Proposed Harbour Defences at San Francisco.—The Adjutant-General of the United States army, in command of the California department, proposes for the defence of the entrance to the Harbour of San Francisco (the "Golden Gate"), the construction of two iron-plated towers, one on Point Bonito, and another on Point Lobos (on both sides of the entrance to the Bay of San Francisco), and, if necessary, another still in the middle of the passage. These plated towers are to rest upon a foundation of masonry, to have dome-shaped revolving roofs or turrets, and to be pierced for two tiers of guns, each tier to mount thirty guns, and the foundation provided with casemated guns. Across the throat of the harbour from fort to fort could be placed a series of massive chains, attached to windlasses moving by steam engines in the forts, which would also revolve the turrets (or roofs) containing the batteries; these chains to be drawn up by the windlass, when required, to such a deflection as to prevent the passage of vessels. This would check the momentum of the vessel, and it would be at point-blank range under the fire of two forts, each capable of delivering a shot every second. As the turret (or tower, or roof, as the upper works are indiscriminately called), revolves, each gun in its turn is brought to bear upon the object direct, and the revolution is made in one minute if desired.

A Wet Dock for Jersey.—In the report issued by the Chamber of Commerce, it is stated that there is every reason to believe that the project for the construction of a wet dock at St. Helier's is about to be carried out. The cost of the wet dock, including a graving dock, is set down at £85,000.

Commercial Harbours.—A parliamentary return recently issued gives the following details of £450,000 estimated for commercial harbours. The estimate is for the coast batteries designed in accordance with the special requirements of each these, viz.—Humber, £70,000; Tyne, £20,000; Sunderland, £20,000; Yarmouth, £10,000; Lowestoft, £10,000; Ramsgate, £6000; Dungeness, £10,000; Poole, £6000; Torbay, £6000; the Severn, £40,000; Swansea, £8000; Holyhead, £25,000; the Mersey, £40,000; the Clyde, £40,000; Aberdeen, £12,000; the Tay, £10,000; Firth or Forth, £40,000; Kingstown, £7000; Belfast, £14,000; Galway, £15,000; Shannon, £10,000; sundry harbours, £30,000—giving a total of £450,000.

New Blackfriars Bridge.—The Committee have duly passed the bill.

MINES, METALLURGY, &c.

Nickel.—Mr. Lewis Thompson, M.R.C.S., in regard to this metal, states, in a recent paper, as follows:—There is every reason to suppose that metallic nickel is an alloy of that metal with cobalt in greater or smaller proportion—that, in fact, absolutely pure nickel has not hitherto been obtained. Pure nickle is, however, much more easily made than pure cobalt, for its affinity for oxygen is much less. Taking advantage of this fact, I made up a quantity of pure oxide of nickel into a paste by means of a little water, and forced this paste through a perforated earthenware plate, so as to form it into a granulated mass; when this mass had been thoroughly dried, I introduced it into a porcelain tube, and after heating it red-hot, I passed a current of pure hydrogen gas over it, and continued this until it had become cold. The grey metallic sponge thus produced was fused with a little borax, in a crucible lined with pure alumina, and yielded a beautiful white silvery-looking button, of the weight of 620 grains; its specific gravity was 8·575, and it was almost as soft as copper. Its malleability seemed very great indeed, for a piece of it was rolled out nearly to the thinness of tinfoil; it showed, however, a disposition to tarnish after a few days' exposure to the air, and then became of a pale yellow colour—a kind of green-sickness tinge. Its magnetic properties were less decided than those of either cobalt or iron; and, judging by the globular form and other evidences of perfect fusion in the button, I believe that nickel is much more fusible than the two just mentioned. When portions of it were melted with copper and zinc, in the quantities usually adopted to form albata, it produced a compound vastly superior in appearance to any of the miserable make-shifts that now disgrace our markets. Indeed, I am quite convinced that it would well repay any respectable person to commence the manufacture of pure nickel, and it would not surprise me if a compound of aluminium and nickel could be formed which, for beauty of appearance, might equal silver, and surpass it in durability and freedom from sulphurous deterioration. Whilst alluding to the advantages of an improvement in the manufacture of nickel, it may not be amiss for me to notice two points of some importance in the way of improvement. At present the extraction of nickel from the ore is made to depend very much upon the affinity of arsenic for that metal, so as to form with it an arseniuret of easy fusibility and sufficient specific gravity to separate freely from the melted slag or gangue; and for this purpose large quantities of arsenic are employed by the workmen, not only to the detriment of their own health, but also to the injury of their neighbours. This pernicious practice is quite unnecessary, as I have myself proved by experiments upon a large scale; for example, after carefully roasting six hundred-weight of the common ore of nickel, which is an arsenio-sulphuret, I mixed it with half its weight of chalk, and threw the mixture into a cubilo furnace in full blast; the result was that the lime of the chalk formed, with the quartz and oxide of iron in the ore, a perfect flux; whilst the oxide of nickel, being easily reduced to the metallic state, fell, in that condition, into the well of the cubilo, from whence it was run out in a melted form, and readily separated from the slag. There was no appreciable loss of nickel in this operation, and the rough metal was found to contain 88 per cent. of pure nickel, the rest being cobalt and iron, with a little sulphur, but no arsenic could be detected in it; moreover, this rough metal might, from the cheapness of the process, have been sold at 3*s.* per lb., and was decidedly more pure than the ordinary commercial nickel. The other point to which I have alluded is applicable to the wet mode of separating nickel, and depends upon a fact hitherto, I believe, unnoticed by chemists. If we have in solution a mixture of the sulphates of nickel, cobalt, zinc, manganese, iron, and copper, we have only to add to this solution, in a warm state, as much sulphate of ammonia as it will dissolve, and then set it aside to cool. Almost every particle of the nickel and cobalt will separate as a green crystallised powder, and leave the other metals in solution. The explanation is very simple. The sulphates of nickel and cobalt form triple salts or alums with the sulphate of ammonia, and these salts are absolutely insoluble in a cold saturated solution of sulphate of ammonia, particularly when this solution is slightly acidulous. I shall conclude these remarks upon nickel by stating that this metal appears to possess the property of "welding" like iron. At my request a workman heated two small bars of nickel, which had been previously powdered over with borax, the bars were heated in a forge, and the two hot ends "jumped" together—that is to say, the white-hot ends were forcibly driven one against the other by gentle blows with a hammer, applied to the other

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ends, the symmetry of the bar being preserved by blows applied laterally. Although the point of junction was afterwards subjected to much twisting, straining, and so forth, with a view to test its cohesive power, yet it showed no signs of weakness, even after much cold hammering.

DIMENSIONS OF THE EARTH'S COALFIELDS.—Professor Rogers states we have it on the authority of competent surveyors, that the great coalfield of South Wales, the largest and deepest in Europe, covers a surface of not less than 1000 square miles, and has a maximum thickness of from 7000 to 12,000 feet in its coal measures. In this prodigious "book of time," there are, it has been commuted, not less than 50 beds of coal, from 6in. to 6ft. in diameter, and 25 of these are said to be each at least 2ft. thick. The smaller Forest of Dean coal basin contains, according to the "Memoirs of the Geological Survey," 31 coal beds in a thickness of coal measures of 2400ft. From the same source (the survey) we learn that the North Staffordshire coal measures have an aggregate depth of about 5000ft.; while those of the Newcastle district are believed to be at least 2000ft. thick, and to embrace a total thickness of coal equivalent to 60ft. In the deepest portions of the extensive coal basin of Scotland, the upper productive coal measures of Mid-Lothian have been found by the survey to possess a thickness of not less than 1800ft. The number of the seams of coal wrought in the Lanarkshire field is in all 18. Turning to other countries, the depths or thicknesses of the coal measures, and the numbers of the coal beds, will be found to be on an equally grand scale. Looking first to the western side of the Atlantic, North America displays, commensurately with the breath of her physical features generally, several enormous coal regions, three at least of which are the largest known upon the globe. One of these, the Appalachian basin, has a length of 875 and a maximum breadth of 180 miles, with an area in square miles of 55,500. Where deepest its coal beds have an aggregate thickness of 40ft. A second, the coalfield of Illinois, Indiana, and Kentucky, has length 370, maximum breadth 200, and area 51,100 miles. This basin has 15 or 16 good coal seams, with a maximum thickness of 50 feet, and the third and largest, but least opened, shows length 550, breath 200, and superficial area 73,913 miles. In the anthracite basin of Pennsylvania the thickness of coal measure, amounts to 3000ft., while that of the workable coal is not less than 120ft. The aggregate area of the five chief coal fields of the American continent amount by careful estimates based upon the latest surveys and the best geological maps, to rather more than 200,000 square miles; a surface greater by about 20 times than the sum of all the coalfields of Europe, or, indeed, of the whole Eastern world. The British carboniferous basins may be estimated to embrace some 5400 square miles of coal; the French a little less than 1000; and the Belgian about 510. Rhenish Prussia has 960; Westphalia 380; the Bohemian field some 400; that of Saxony only 30; that of Spain probably 200; and that of all Russia scarcely 100 square miles. Comparing the coal areas with the total surfaces of the respective coal producing countries, the United States has one square mile of coal to each 15 of land; Great Britain one to every 22½; Belgium a like proportion; and France but one of coal to every 200 of country. Adopting for the commuted total area of the coalfields of the world 220,000 square miles, and accepting 20 feet (a low estimate) for the average thickness of the available coal, the entire mass of the fuel under the soil for the future wants of man amounts by calculation to a cubic lump of nearly ten miles lineal dimensions, or to a square plateau of coals 100 miles wide in its base, and something more than 500ft. in height. The British lump of coal is a cube of a little more than three miles in diameter. In 1854 Great Britain extracted from her mines more than 64,000,000 tons. In 1861 the product was about 80,000,000 tons, equal to a cubic block of 430 yards in height. For the present year the probable product may be safely estimated at not less than the enormous quantity of 100,000,000 of tons. In the preliminary report lately printed on the census of the United States for 1860, it is shown that the coal product of the state of Pennsylvania amounted in that year to about 11,500,000 tons, while that of all the coal yielding states together exceeded 15,000,000 tons. In the year 1850 Belgium took from her mines nearly 6,000,000 tons; France some 4,500,000 tons, and Prussia nearly 4,000,000 tons. It has been calculated that one-fifth at least of the present vast product in coal of the civilised world, which fifth part we may roughly estimate at nearly 30,000,000 tons annually, is applied in the smelting and manufacture of iron alone, and it is probable that more than one-tenth of the whole of the fuel lifted, or some 15,000,000 tons, is converted directly into mechanical power, through the generation of steam for the propulsion of machinery.

LEAD AND LEAD ALLOYS.—It has been generally supposed that the purer a metal, the less it is acted upon by acids; and Messrs. Crace-Calvert and Johnson, in some important researches in connection with lead, considered it very desirable to ascertain, at least, whether the generally received opinion was correct as regards lead. They commenced with sulphuric acid on commercial lead, because that metal is extensively employed in the construction of those large chambers in which sulphuric acid is manufactured; this course combined scientific interest with practical utility. In the experiments which they instituted, they employed sulphuric acid of various degrees of concentration and purity in different volumes at various temperatures, and for various periods of time. They have made use of two kinds of commercial lead, choosing as types the two extremes in respect of purity—common sheet lead representing ordinary impure lead, and virgin or Derbyshire pig-lead. They have also thought it desirable to examine the action of chemically pure lead. The common lead, upon assay, gave—Lead, 98·8175; tin, 0·3955; iron, 0·3604; copper, 0·4026; zinc, traces = 99·9760; and the virgin lead gave—Lead, 99·2060; tin, 0·0120; iron, 0·3246; copper, 0·4374; zinc, traces = 99·9800. At the ordinary temperature (18° to 20° cent.) perfectly pure sulphuric acid of the density stated dissolved from a square metre of surface the following quantities (in grammes) of each kind of lead :—

Density of acid.	In ten days. Common.	Virgin.	Pure.	In fifteen days. Common.	Virgin.	Pure.
1·842	67·70	134·20	201·70	89·00	194·34	279·00
1·705	8·35	16·50	19·70	11·67	16·84	24·00
1·600	5·55	10·34	16·20	6·17	12·17	20·00
1·526	2·17	4·34	6·84	3·17	8·67	10·67

These results leave no doubt that the purer the lead the more it is attacked, and that in a ratio which is very curious and instructive. The result of the fifteen day experiment fully confirms the ten day experiment, and even with heated acid a similar result is obtained. They operated with acid at a temperature of above 45° cent. for eight days, when the result was—

Density of acid.	Common.	Virgin.	Pure.
1·842	418·34	458·50	507·34
1·705	6·84	10·67	13·00
1·600	5·84	6·34	11·84
1·525	3·50	4·84	6·67

The question then occurred to them whether the purity of the acid employed had occasioned such unexpected results. They, therefore, tried other experiments with acid from the leaden chamber (density 1593), and with acid not as it comes from the leaden chamber, but after having been once evaporated in open leaden vessels, in which its concentration is commenced commercially (density 1·748). The results obtained were—

	Common.	Virgin.	Pure.	Common.	Virgin.	Pure.
A	11·84	15·84	19·50	11·34	16·77	19·84
B	20·17	22·50	27·00	22·17	24·34	27·67
C	49·67	50·84	55·00	51·91	54·75	57·41
D	54·67	56·17	59·34	56·25	58·67	60·67

In the above table the mean results of two distinct series of experiments of each class of 15 days duration are given. In the experiments A, 16·666 litres of 1·593 acid, at a temperature of 45° to 48° cent. was used; in the experiments B, the quantity of acid was doubled, other conditions remaining the same; in the experiment C, 16·666 litres of 1·748 acid, at a temperature of 113° to 122° cent was used; and in the experiments D the quantity of acid was doubled, other conditions remaining the same. The conclusions which Messrs. Calvert and Johnson have drawn from their experiments are—Firstly, that of the various kinds of lead existing in commerce, the purer they are the more they are acted upon by sulphuric acid; lead chemically pure is more acted upon than any of the others. Secondly, that although it is stated in many works on chemistry that sulphuric acid only acts sensibly on lead at a temperature of 195° cent., their experiments tend to prove the contrary, since they find that acid of specific gravity 1·842 dissolves cold 67·134, and even 201 grammes of lead per square metre of surface; and in another instance, that acid of specific gravity 1·705 takes from the same surface 54, 56, and 59 grammes of lead, at a temperature of 45° cent. only; and, lastly, that the action of sulphuric acid upon lead appears, at least when there is no continuous agitation of the mass, not to increase in proportion to the quantity of acid employed—this is probably due to the formation of a layer of sulphate of lead, which, to a great extent, protects the surface from further action of the acid. From the analysis of lead chambers with respect to which they were consulted by a large chemical manufacturer, one which had lasted 15 years, was found to be composed of an alloy of—lead, 98·87; tin, 0·91; iron, 0·12, with traces of copper and zinc; whilst two others, injured in less than one year, contained only traces of tin, the alloy being about 99·4 lead, 0·35 iron, and 0·16 copper and zinc.

APPLIED CHEMISTRY.

ANALYTICAL NOTICES ON URANIUM, BY M. H. ROSE.—Oxide of uranium may be completely precipitated from its acid solutions, having previously saturated them with ammonia, by addition of hydrosulphate of ammonia. No inconvenience results from the solution containing many ammoniacal salts, excepting, of course, carbonate of ammonia and all alkaline carbonates. The precipitate is black, or reddish brown if the hydrosulphate be greatly in excess. It is washed in water, to which is added a small quantity of hydrosulphate of ammonia. The precipitate is formed essentially of protoxide of uraniam, and contains no sulphide of uranium. After being dried, it is ignited, to expel what little sulphur may be retained; then it is calcined in a hyprogen current, at a high temperature, and left to cool in the hydrogen. Pure protoxide is thus obtained. Should the solution contain much salts of potash, or of other strong non-volatile bases, the precipitate will retain a small quantity of these bases. Oxide of uranium is separable in the following manner from most metals, especially from those which are completely precipitated from their solutions by hydrosulphate of ammonia :—Add to the solution excess of carbonate of ammonia mixed with hydrosulphate. All the oxides which hydrosulphate transforms into sulphides are precipitated, while the protoxide of uranium is dissolved in the carbonate of ammonia. Leave the mixture to deposit in a closed vessel, wash the precipitate by decantation, with water containing carbonate and hydrosulphate of ammonia, and then filter. Gently heat the filtered liquid, to expel most of the carbonate; decompose the hydrosulphate with hydrochloric acid; oxidize the protoxide of uranium by nitric acid, and precipitate the oxide by ammonia, and, before weighing, calcine it in a hydrogen current.

COMPOSITION OF GAS REFUSE BY DR. T. L. PHIPSON.—It has been estimated that one ton of Newcastle coal gives off in distillation as much cyanogen as is contained in five to eight pounds of Prussian blue. As sulphuretted hydrogen is disengaged at the same time in greater or smaller quantities, according to the nature of the coal, it is natural that sulphocyanides should form also. My attention having been lately directed to gas-refuse obtained after eliminating the sulphuretted hodrogen and carbonic acid by hydrated oxide of lime and lime purifiers, I found in this substance certain sulphocyanides, and it occurred to me that it might prove a source of sulphocyanide of ammonium for photograpic purposes. But the samples I have hitherto examined, having been used as long as possible, with a view of obtaining the maximum amount of sulphur, have not promised so much sulphocyanide as I should expect to find in the refuse purifiers which had not been employed for so long a period. It is curious to note, however, that this substance, which is offered to manufacturers of sulphuric acid on account of the sulphur it contains, has also been recommended to makers of artificial manures and to agriculturists as a cheap source of nitrogen! It will be seen by the analysis I subjoin that the employment of this substance for agricultural purposes is not only useless, but may become highly injurious to any soil. Besides the cyanogen compounds I have found in it, and which must be considered as prejudicial to vegetation, the existence of tar-products, highly antiseptic, and therefore capable of preventing organic decomposition in the soil—a process indispensable to vegetation—is evident; it contains also a very large amount of free sulphur. When this gas-refuse has been exposed for some time to the air it contains the following substances :—Free sulphur in considerable quantity, oxide of iron, carbonate of lime, cellulose in small quantity, some hydrocarbons soluble in alcohol, double cyanide of iron (green), ferrocyanide of iron (blue), sulphocyanide of calcium, sulphocyanide of ammonium, chloride of ammonium, sulphate of lime, ferrocyanhydric acid (to which the mass owes its acid reaction), and water. Some of these are present in small quantity only, but it is not difficult to putthem all in evidence. A rough analysis of the whole has given me :—

Water	14·0
Sulphur	60·0
Organic matters insoluble in alcohol	3·0
Organic matters soluble in alcohol : sulphocyanide of calcium, chloride of ammonium, hydrocarbons, &c.	1·5
Clay and sand	8·0
Carbonate of lime, oxide of iron, &c.	13·5
	100·0

Hot water extracts sulphocyanide of calcium and ammonium, sulphate of lime, and ferrocyanhydric acid. The solution takes a red colour with persalts of iron. Hydrochloric acid disolves a considerable amount of the substance, and the solution obtained is deep-blood red, almost opaque, from the presence of sulphocyanide of iron formed. Alcohol extracts principally sulphocyanides of calcium and ammonium, chloride of ammonium, a small quantity of hydrocarbons, and ferrocyanhydric acid. By evaporating the aqueous solution to dryness, after having added enough carbonate of potash to neutralise its acidity, and treating the residue by alcohol, the ferrocyanhydric acid is left behind as ferrocyanide of potassium, and the alcoholic solution contains only chloride of ammonium and sulphocyanides of calcium and ammonium. By evaporating in presence of an excess of carbonate of potash to complete dryness, and treating with alcohol, the latter takes up principally sulphocyanide of potassium, and by using carbonate of ammonia, in place of carbonate of potash, the alcoholic solution consists of sulphocyanide and chloride of ammonium, which would serve for fixing photographic proofs. The green compound which forms when gas-refuse is exposed to the air, is no other than the double cyanide of iron, $FeCy + Fe_2Cy_3$, discovered by Pelouze, the composition of which corresponds to magnetic oxide. By prolonged oxidation in the air it becomes blue; most acids have no action on it, but hot nitric acid decomposes it.

A CURIOUS CHEMICAL DISCOVERY has been made by Dissenbacher, a young German chemist. By the addition of a small quantity of chlorine or iodine, pure sulphur is rendered perfectly soft, and the Paris Academy, to whom the the experiment was exhibited by H. Deville, were astonished to see a thin leaf of sulphur treated as flexible as if made of wax.

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LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

DATED MARCH 24th, 1863.

768 H. Cook—Transmitting electric currents and signals for telegraphic purposes.
769 J. Reilly & W. Martin—Lubricating horizontal shafting and bearings of all descriptions.
770 G. Davies—Wrappers or papers for needles, and machinery for sticking needles therein.
771 S. Healey—Zinc.
772 H. Williams—Dressing slates.
773 A., J., & J. Topham—Ornamental twist lace.
774 J. Kirkham—Iron and steel.
775 A. J. Cooke—Portable "Hooka" pipes.

DATED MARCH 25th, 1863.

776 J. White—Protecting the surface of the iron and steel of ships.
777 M. Phillips—Iron or other metallic rod and wire.
778 J. Leach & J. Anderson—Preparing and spinning cotton and other fibrous substances.
779 J. H. Worrall—Producing surfaces in imitation of woods, and in printing therefrom.
780 G. Stuart—Bleaching jute fibre.
781 C. Monson—Gravitation engine.
782 R. Armitage & C. Sumner—Stretching fabrics.
783 J. H. Johnson—Zinc.
784 T. Wilson—Uniting earthenware, metal, and other pipes.
785 R. A. Brooman—Cords, ropes, and cables.
786 G. T. Key—Fog and other signals.

DATED MARCH 26th, 1863.

787 L. Christofleau—Fire-arms.
788 R. Mushet—Treating steel and iron prepared by the pneumatic process.
789 G. Cowdery—Making bricks.
790 M. L. Parnell—Construction of locks and adjusting their spindles.
791 N. R. Hall—Weighing apparatus.
792 W. Johnson—Pocket books, purses, wallets, and bill cases.
793 T. Parkinson & J. Wood—Application of embroidery to certain printed fabrics.
794 W. Tod & R. Paterson—Portable apparatus for working drills and other instruments.
795 G. Davies—Engraving upon metals.
796 J. H. Johnson—Furnaces or fire-places.
797 J. Norton—Projectiles or ignition missiles.
798 W. Blake—Labels for luggage and other articles.
799 F. Applegate—Railway carriage doors.
800 E. Easton—Hydraulic apparatus for lowering full casks and other goods, and raising empty casks or vessels.

DATED MARCH 27th, 1863.

801 J. Grantham—Apparatus connected with machinery used in manufacturing compressed fuel.
802 W. M. Morgan—Coating metals.
803 R. A. Brooman—Scouring wool.
804 J. Taylor—Rain water pipes.
805 W. Clark—Winding or copping frames.
806 J. D. Asquith & G. Greenwood—Rag machines.
807 J. King & T. H. Marshall—Preparing land for seed.

DATED MARCH 28th, 1863.

808 B. W. Goode—Journal, axle, or bearing.
809 A. H. Perry—Working railway points, switches, and signals.
810 R. Sims—Reaping and mowing machines.
811 J. Leeming & R. S. Markindale—Carding engines.
812 A. Blouin & D. N. Mercier—Axletree with linked levers or lifting.
813 W. Symons—Barometers.
814 G. Thomas—Window shutters and blinds.
815 J. Dale & G. Beschof—Aniline, napthylamine, and other analogous bodies.

DATED MARCH 30th, 1863.

816 J. Musgrave—Steam boilers.
817 T. Barnes—Treating fats and fatty oils and volatile oils or essential oils.
818 R. Mushet—Moulds for casting steel or homogeneous iron.
819 H. Hughes—Shaping metal and plastic substances.
820 J. Carver—Carriages employed in machines for the making of lace or other fabrics.
821 W. E. Newton—Process for producing yellow colouring matters.
822 W. Ager—Decorticating and decorticating grain.
823 J. Payne—Fire escapes.

DATED MARCH 31st, 1863.

824 E. T. Hughes—Composition for rendering cloth, paper, and similar articles transparent and waterproof.
825 J. Smethurst—Steam engines and boilers.
826 A. B. D. Maurand—Translucid cylindric apparatus for bringing the former weights and measures into those of the present decimal system most easily and precisely, and vice versa.
827 R. Parsival—Plaiting or braiding machines.
828 W. Forrest & H. Duckworth—Looms for weaving.
829 A. H. & V. F. Bell—Constructing the armour of vessels of war.
830 R. A. Brooman—Electric telegraph printing apparatus.
831 R. O. Coe—Propellers for ships and other vessels.
832 H. Hamer—Tanning.
833 J. M. Dunlop—Ginning cotton.

DATED APRIL 1st, 1863.

834 J. S. Grimshaw—Carding engines.
835 J. Hindle, W. F. Calvert, & E. Thornton—Looms for weaving.
836 I. Rowland—Mileage apparatus for measuring and registering the distances public vehicles or private carriages travel.
837 J. Bray—Omnibuses, railway carriages, and other vehicles.
838 M. Henry—Lubricating.
839 W. Clark—Preventing fermentation in alcoholic and other liquids while drawing them from their containing vessels.
840 W. West—Working railway signals.
841 W. Mitchell—Coating iron.
842 G. T. Bousfield—Steam boilers.
843 E. B. Wilson—Iron and steel and other metals.
844 R. Gavin—Preservation of perishable liquids during the withdrawal or consumption thereof.

DATED APRIL 2nd, 1863.

845 W. H. Phillips—Cleaning the bottoms of ships or other floating vessels.
846 J. W. Law & J. Inglis—Making moulds for casting.
847 E. F. Clarke—Fastening rails for railways.
848 D. S. Sutherland—Protecting vessels of war and fortifications from the effects of projectiles.
849 J. Cassell—Stills for the distillation of petroleum and other heavy oils.
850 J. J. Potel—Furnaces and fire-places.
851 W. Jones—Ships or vessels.
852 G. A. Cox—Preparation and manufacture of jute, hemp, flax, and other fibrous or textile materials.
853 A. P. Price—Fusion, manufacture, production, and refining of metals.
854 A. B. Seithen—Casings, covers, or wrappers for bottles, jars, and other articles.

DATED APRIL 4th, 1863.

855 A. Stewart—Saddles.
856 J. Blain—Finishing threads and yarns.
857 J. P. Hunrez—Drying coal, grain, and other substances.
858 J. Silvester—Attaching guards to pressure gauges.
859 W. H. Perkin—Red and orange colouring matters.
860 W. E. Gedge—Bolting flour.
861 J. Gimson—Actuating shuttles in looms for weaving narrow fabrics.
862 A. V. Newton—Pressure gauge.
863 P. Spence—Sulphuric acid and sulphate of iron.

DATED APRIL 6th, 1863.

864 F. C. Bakewell—Wicks for lamps.
865 B. Cooper—Feeding, scribbling, or carding engines.
866 T. Burrow—Combing or dressing silk, flax, wool, hemp, China grass, or other fibrous materials.
867 W. E. Gedge—Aerial machines.
868 M. Henry—Probes, catheters, and similar surgical instruments.
869 J. Railton—Carding cotton and other fibrous substances.
870 J. Burwin—Pickers.
871 E. T. Hughes—Ornamental tips of parasols, umbrellas, and similar articles.

DATED APRIL 7th, 1863.

872 J. Swinburne & J. Stanley—Steam engines and generators.
873 H. Gibbe—Composition for dressing and preparing silk, cotton, and woollen tissues and fibres, and also mixtures of the same.
874 A. C. Bamlett—Reaping and mowing machines.
875 J. Macintyre—Knobs and other articles in china and earthenware.
876 J. H. Johnson—Drying grain.
877 J. H. Johnson—Polishing precious and other hard stones.
878 R. A. Brooman—Baryta and its derivatives, obtaining by-products, and revivifying or recovering certain agents employed in such manufacture.
879 R. A. Brooman—Obtaining fac-similes of the veins, pores, knots, and figures of wood upon paper and other surfaces.
880 J. Howard, E. T. Bousfield, & J. Pinney—Steam engines.
881 A. V. Newton—Projectiles for ordnance, and fuses therefor.
882 G. H. & W. R. Hill—Steam boilers.

DATED APRIL 8th, 1863.

883 W. Simpson—Insulating the magnetic needle or needles in compasses.
884 J. Mosheimer—Crushing, grinding, and dressing metallic ores, quartz, and other similar substances.
885 J. N. Brown—Connecting the bearing springs of railway carriages and waggons to the axle boxes of the said carriages and waggons.
886 T. Gray—Preparing and bleaching jute and other vegetable fibres for spinning and other purposes.
887 J. R. Harris—Propelling vessels.
888 W. E. Gedge—Propelling and navigating small craft.
889 W. H. Mitchel—Barometer.
890 J. L. Norton—Washing and drying wool and other fibres and rags, and tentering, stretching, and drying fabrics.
891 A. Kinder—Covering lead or alloys of lead with tin or alloys of tin.

DATED APRIL 9th, 1863.

892 H. B. Fox—Dish covers.
893 D. J. Cooke—Compositions for sizing, stiffening, and colouring yarns and texile fabrics.
894 T. F. Heath—Ceilings.
895 F. J. Risse—Universal haft or handle.
896 G. Spencer—Preventing incrustation in steam engine boilers.
897 A. Hett & F. W. Basset—Preventing the fouling of ships' bottoms, and cleansing the same when foulest.
898 J. Rudley & D. McColl—Preventing the escape of fumes and matters from furnaces.
899 R. K. Penson—Warming railway carriages.
900 J. R. Burton—Cleansing ships' bottoms.
901 G. Ferrand—Supplying oil or other liquid lubricant to frictional surfaces.
902 A. V. Newton—Offensive weapon.
903 G. Low—Machinery for boring rocks and other hard substances.
904 A. V. Newton—Stirrups, and the mode of attaching the same to saddles.

DATED APRIL 10th, 1863.

905 G. Colomb—Manufacturing factitious blocks of wood of diversified shades and hues proper for veneering and other purposes.
906 S. A. Couperie—Semi-circular metallic slide.
907 T. Baldwin—Superheating steam.
908 S. Shelmerdine & J. Dransfield—Ornamentation by printing of felt hats.
909 H. R. Spicer—Cases for the enclosure and preservation of human remains.
910 R. Smith—Medicated oil for the preservation of metal, wood, or stone.
911 J. Watkinson & C. Dening—Horse rakers.
912 J. Gimson—Screw cutting lathes.
913 H. W. Ripley—Preparing and printing wool and other fibres.
914 H. Candwell—Vessels of war.

DATED APRIL 11th, 1863.

915 F. Versmann—Moulding machines.
916 J. Lockwood—Steam boiler and other furnaces.
917 D. Mairs—Fire-bars or furnaces grids.
918 W. Samuel—Improvements in railway carriages to mitigate or lessen the effects of collisions to passengers.
919 J. Farrar—Twisting or doubling yarns of wool or other fibrous substances.
920 W. Clark—Separating ores from their gangues.
921 P. P. Baly—Breakwaters, piers, sea walls, and other similar structures.
922 A. F. Maclure—Looms for weaving figured fabrics.
923 C. A. Collins—Loading cars and waggons with hay, straw, and other similar products.

DATED APRIL 13th, 1863.

924 J. Ramsbottom—Hammering, rolling, and shaping metals.
925 J. Gill—Printing machinery.
926 A. Roffe—Propelling carriages on railways, tramways, or on common roads.
927 R. Legg jr. & R. Gittus—Cutting chaff and other agricultural produce.
928 J. Lark—Artificial fuel and cement.
929 R. Reeves—Liquid manure drills.
930 R. Newton—Separating and straightening the fibres of silk waste and other fibrous substances.
931 M. Myers—Trunks, portmanteaus, and boxes.
932 T. Mallinson & P. Williams—Opening, cleaning, carding, and grinding or sharpening cards used in preparing cotton and other fibrous materials.

DATED APRIL 14th, 1863.

933 J. Nasmith & S. Thornton—Carding cotton and other fibrous substances.
934 G. Berry—Locks.
935 G. T. Smith—Metallic window shutters.
936 W. & J. Kents—Boots, shoes, or other coverings for the feet.
937 J. Combe & J. H. Smalpage—Machines for winding cops.
938 J. Kents & W. S. Clarke—Sewing machines.
939 H. Trapnell—Vent pegs.
940 R. A. Brooman—Hardening and colouring gypseous limestone and sand and calcareous stones.
941 R. A. Brooman—Lamps for burning light and heavy mineral and vegetable oils.
942 J. Smith—Furnaces and boilers for the generation of steam.

DATED APRIL 15th, 1863.

943 J. Leach—Washing, squeezing, mangling, and and churning.
944 E. P. Colquhoun & J. P. Ferris—Fire bars for the furnaces of steam boilers and fire-grates.
945 T. Gray—Preparing flax, hemp, and other fibres, by which a brilliant lustre is imparted to those substances, and the fibres are separated.
946 W. Clark—Apparatus for the transport of goods.
947 R. A. Bonneville—Gas burners.
948 A. Marriott—Boilers for heating buildings, and regulators for the same.
949 W. Spence—Gunpowder.
950 H. Eaton—Presses for bailing purposes.
951 J. S. Morton—Locks.
952 A. V. Newton—Blowing apparatus.
953 T. B. E. Fletcher—Apparatus for collecting the solid portions of sewage.

DATED APRIL 16th, 1863.

954 J. B. Watts—Steel sword hilts.
955 J. L. McLay—Mariners compasses.
956 I. Bagge & W. Simpson—Purifying and treating coal gas, sulphuretted hydrogen, and other gases containing sulphuretted hydrogen, and obtaining sulphur, sulphuric and other acids in such treatment.
957 C. Ferrett—Preventing incrustation in steam boilers.
958 S. Moulton—Lessening the recoil of cannon.
959 W. Oldfield—Locks.
960 A. Samuelson—Oil.
961 T. A. W. Clarke—Shuttle driver.
962 P. A. E. Gurnmuscle Masana—Smut machines, and machines for cleansing and peeling grain and seeds.

DATED APRIL 17th, 1863.

963 R. Knight—Treating and preparing iron, copper, and other wires for telegraphic and other uses for the purpose of preserving them from corrosion or decay.
964 S. Riley—Cocoa and chocolate.
965 J. & T. Richmond & D. Harling—Looms for weaving.
966 J. Goucher—Steam boilers, and regulating the admission of air into the furnaces of steam boilers.
967 R. C. Clapham—Treating the waste liquor from bleaching powder stills in order to obtain hydrochloric acid and other products therefrom.
968 R. H. Lawson & W. Darlow—Obtaining motive power.
969 W. Massingham—Apparatus for cooling liquids.
970 C. Turner—Felted fabrics.
971 B. J. Webber—Separating corn from the ears, and for combing straw.

DATED APRIL 18th, 1863.

972 C. W. & F. Siemens—Furnaces which are principally applicable to the smelting of iron.
973 W. S. Macdonald—Drying animal, vegetable, and mineral substances.
974 T. A. Weston—Ratchet levers.
975 W. B. Barden—Wheels and axles applicable to locomotives, carriages, and paddle wheels.
976 G. A. Buchholz—Hulling grain and reducing granular substances.
977 T. Hunt—Obtaining motive power.

DATED APRIL 20th, 1863.

978 P. G. Rowell & H. Holt—Securing the bands of locomotive engine and tender springs.
979 C. Randolph & J. Elder—Surface condensers.
980 G., W., and J. Graham—Folding or plaiting fabrics.
981 C. Blanc—Combinator for the purpose of using air and steam as motive power.
982 J. Robey—Separating fluids from more solid matters.
983 W. E. Newton—Lamps.
984 E. W. Hughes—Turn tables, turn bridges, and slips.

DATED APRIL 21st, 1863.

985 A. Ford and R. Rigg—Re-forming and reusing old or waste vulcanized india rubber.
986 H. Rafen—Obtaining printing surfaces.
987 J. Heap—Adjustable wrenches for nuts, pipes, and pins.
988 E. L. Simpson—Water-proof compounds.
989 N. P. C. Lloyd—Atmospheric engine.
990 M. Runkel—Marine steam engine governors.
991 J. W. Nottingham—Two-wheeled vehicles.
992 H., E., & J. Yeadon—Healds for weaving.
993 H. Donald—Bending or straightening metal plates.
994 W. E. Newton—Wrenches.
995 W. C. Cambridge—Harrows.
996 W. Campion and G. Wilson—Looped fabrics.
997 W. Ryan and W. Daniel—Transmitting, equalizing, and registering human power.

DATED APRIL 22nd, 1863.

998 F. E. Bryant—Ascertaining the temperature of steam and its power of tension.
999 J. Settle—Roving, slubbing, and spinning cotton and other fibrous substances.
1000 F. Durand—Moulding articles of china or other clay or of other plastic materials.
1001 T. Grace—Reaping and mowing machines.
1002 H. B. Barlow—Shoes, boots, and other coverings for the feet.
1003 E. J. Jeffs and T. Turner—Carriage ways.
1004 W. Clark—Obtaining publicity.
1005 J. Lee and E. Dawson—Looms for weaving.
1006 G. B. Barber—Steam boilers.

DATED APRIL 23rd, 1863.

1007 J. W. Proffitt and W. L. Duncan—Distributing sand and other substances on the rails of railways and tramways.
1008 J. Whitley, J. B. Pope, and J. W. Burton—Metals.
1009 R. Richardson—Railway permanent way.
1010 W. E. Newton—Repairing worn out files.
1011 W. Clark—Tiles.
1012 T. Richardson and J. C. Stevenson—Sulphate of soda.
1013 P. McGregor—Spinning and doubling.

DATED APRIL 24th, 1863.

1014 J. Cavanah—Cricket bats.
1015 J. B. Daines—Preparation of stone.
1016 W. N. Wilson and J. G. Grey—Sewing.
1017 J. Lambert—Hall cocks.
1018 J. Sheppard—Steam engines.
1019 J. Knowles and S. Jackson—Heating water.
1020 R. Lavender—Lubricator.
1021 P. Passavant—Colouring matters.
1022 J. Cornes and C. Davis—Lawn mowing machines.
1023 J. Thompson—Barrels for fire-arms.
1024 J. Thompson—Punching metals.
1025 W. A. Shaw—Lining lead pipe with tin.
1026 J. Hinks and J. Newman—Buttons.
1027 J. H. Johnson—Treating oils.

DATED APRIL 25th, 1863.

1028 C. Pooley—Preparing and spinning cotton.
1029 L. de Breanski—Fixing drills.
1030 S. Harrison—Type.
1031 A. H. Clark and H. Hope—Valves.
1032 T. A. Weston and C. Vivian—Pulleys.
1033 J. P. and E. B. Nunn—Cultivators.
1034 J. Dunbar and J. N. Woodford—Steering ships.

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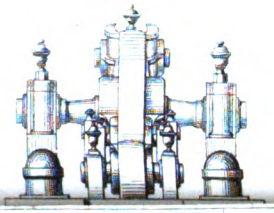
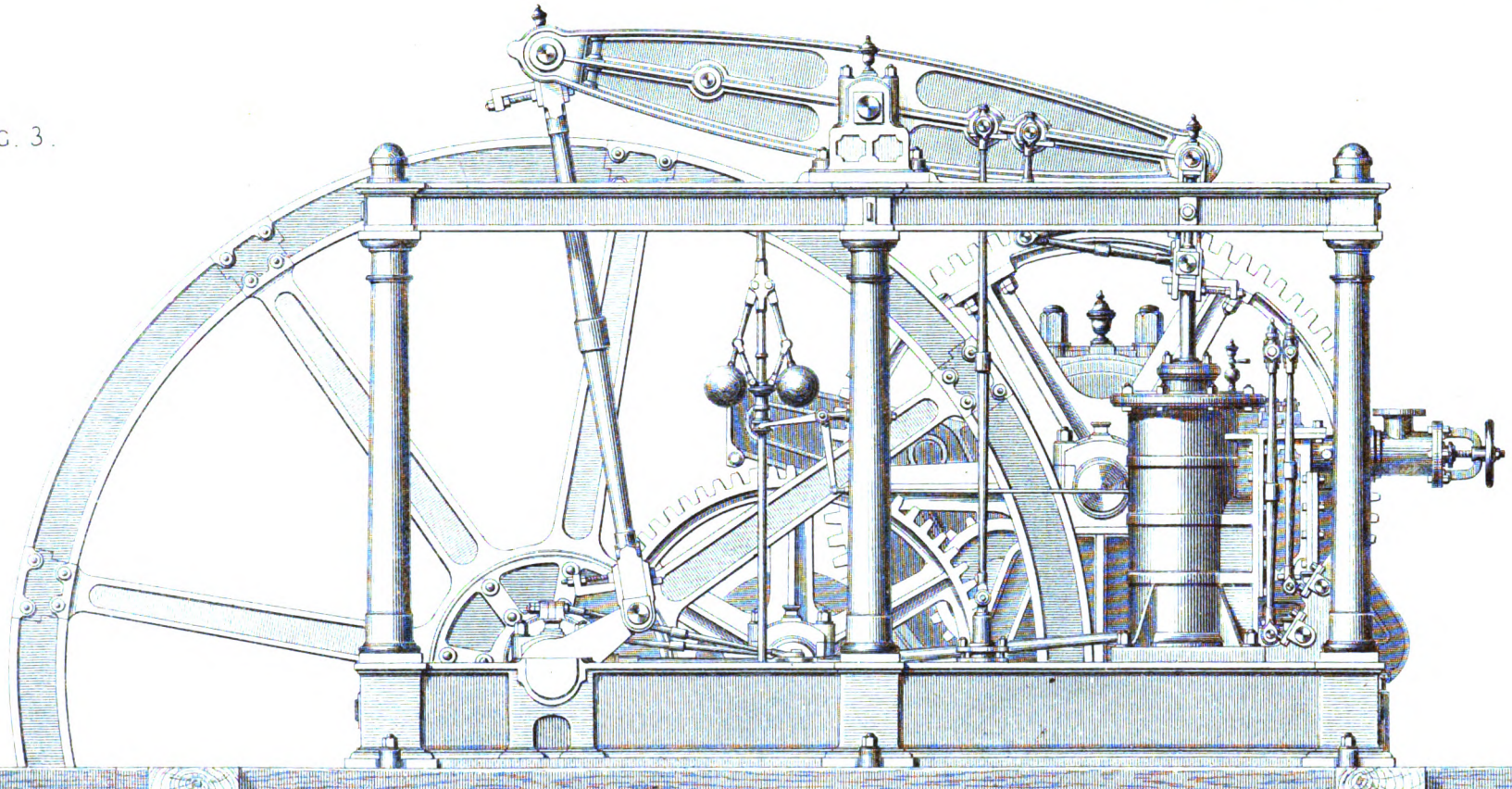


STEAM ENGINE AND SUGAR MILL,

CONSTRUCTED BY MESSRS W & A McONIE, *ENGINEERS,*

FIG. 3.



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LOCOMOTIVE ENGINEERING.

FIG: 1.

FIG. 2.

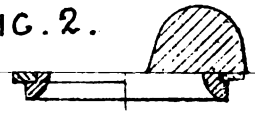


FIG: 16.

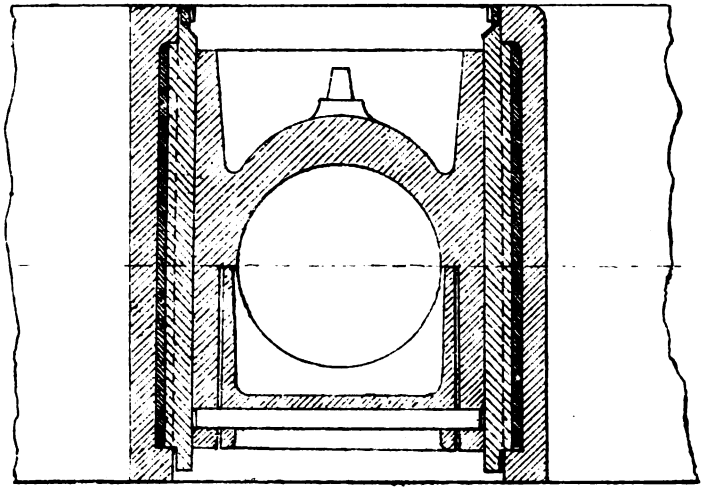


FIG: 19.

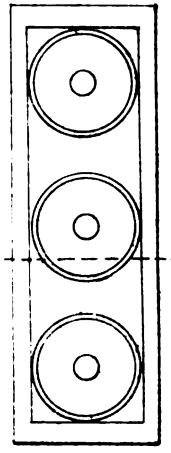


FIG: 18.

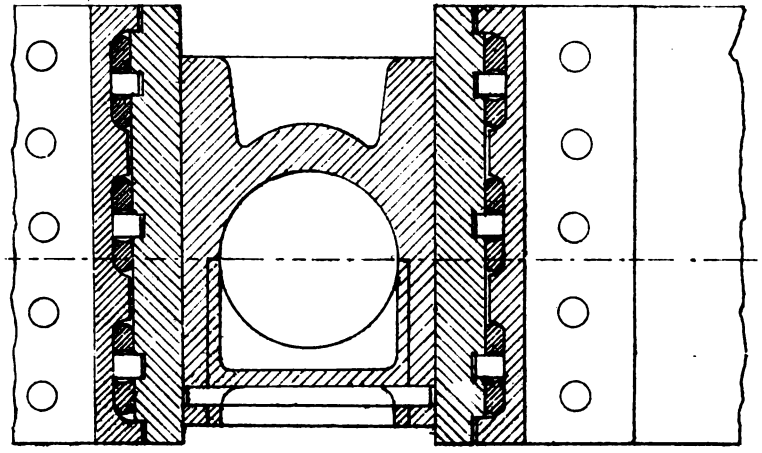


FIG: 17.

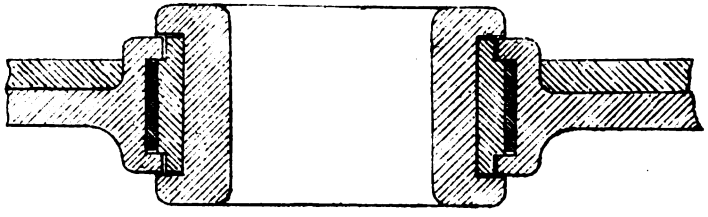
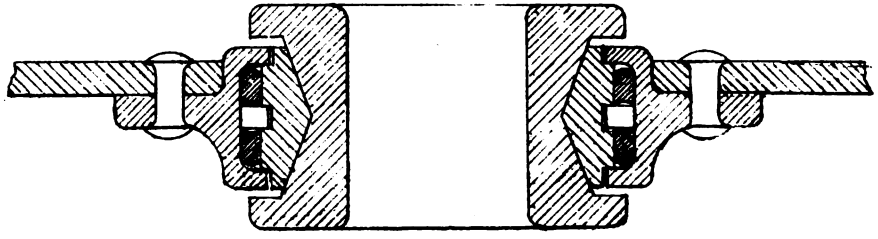


FIG: 20.



Smith. C E direx.

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THE ARTIZAN.

No. 6.—Vol. 1.—Third Series.

JUNE 1st, 1863.

STEAM ENGINE AND SUGAR MILL.

Constructed by Messrs. M'Onie Bros., Engineers, Glasgow.

(*Illustrated by Plate* 242.)

Plate 242, accompanying the present number, illustrates the larger of the two sugar mills, with the engine for driving it, exhibited at the late International Exhibition, by Messrs. M'Onie Bros., of Glasgow, who have acquired a well-earned reputation for the production of this class of machinery. In our Plate, Fig. 1 is a front elevational view of the steam engine and sugar mill; Fig. 2, a side elevation of the same; and Fig. 3, an end elevation thereof.

We have already had occasion to allude to Messrs. M'Onie's sugar machinery in our series of Artizan Exhibition Supplements; and in No. 3 of that series, we illustrated a portion of the machinery exhibited by that firm.

The sugar mill illustrated by the accompanying Plate is worked by a high pressure steam engine of 30 nominal horse power, fitted with the usual short slide valve, and an expansion valve arranged to cut off the steam at any part of the stroke. The diameter of steam cylinder is 21in., and the stroke 3ft. 6in. The fly-wheel is 18ft. diameter, and the main shaft and other motive parts are all of forged iron. The engine is regulated to run at 35 strokes per minute, and with high pressure, steam is capable of being worked up to 60, to 80 indicated H.P.

The connection of the engine power to drive the cane mill is carried through a set of double gear spur wheels, which with their shafts and gearing standards, are all securely arranged inside, and fixed to, a strong bed casting. The speed of the steam engine and gearing is arranged so that the surface of the periphery of the cane mill rollers moves about 19ft. per minute.

The sugar cane mill is of the usual three-rollered form—rollers, 5½ft. long by 28in. diameter. The mill bed forms the receiver for the juice; and the side framings for carrying the rollers are so constructed that any of the rollers can be removed, if occasion occurs for such, without dismantling the framework.

The steam engine with its sugar mill is of a size frequently sent out to the sugar estates, and is capable of grinding canes for making 10 to 12 tons of sugar daily. The weight of the machinery (exclusive of boiler) is about 75 tons.

The smaller, or cattle power sugar mill previously alluded to, was, in general arrangement, similar to the larger mill, but having the necessary attachments for the bullocks or mules.

We may add that the machinery—the subject of our plate—was, at the close of the Exhibition, forwarded direct from London to Trinidad, to the Brechin Castle estate of Messrs. Gregor, Turnbull and Co., of Glasgow.

A CRITICAL AND HISTORICAL REVIEW OF LOCOMOTIVE ENGINEERING.

By J. J. Birckel.

(*Illustrated by Plate* 243.)

(*Continued from page* 102.)

Closely connected with the general question of stability of the engine is that of the state of repair of the carriage proper and especially that of the wheel tyres, the axle bearings, and the axle-boxes. One great cause of instability of the engine is the want of parallelism of the axles, the tendency of which is to divert the engine from its straight course and to produce, or to assist in producing, that sinuous motion, already spoken of when treating of the disturbing element of the parts of machinery in motion. The parallelism is especially affected by the play of the axles in their bearings and of the axle boxes in the frame cheeks, or horn plates, the structure and construction of all which should, therefore, be such as to offer the least possible liability to wear. The realization of this object has been aimed at both in the axle bearings and in the frame cheeks, by providing as large a frictional surface as possible, and in journals by increasing their length when the condition of strength and durability of the axle as affected by its diametre is satisfied; in driving axles the diameter of inside bearings varies from 5 to 7½in., according to the size of the engine, these being very likely the extreme limits in locomotives for ordinary traffic; the length of the journal, which 15 years ago probably never amounted to 7in. in any of the engines upon the narrow guage, now very frequently reaches the somewhat large dimension of 10in., and is seldom less than 7in. When the axle has both inside and outside bearings, these are generally smaller in diameter but at the same time longer, though without any definite ratio to the inside ones. Mr. Clark, it is true, adduces very plausible reasons to show that the frictional area of the inner ones should be considerably larger than that of the outer ones, yet in practice the opposite more generally occurs, for the very simple reason that when room is provided for a capacious inside bearing, the engineer prefers to dispense with the outside one altogether. In coupled engines the dimensions of the journals of the leading and trailing axles are generally equal to those of the driving axle, for the sake of simplicity; in uncoupled engines their diameter varies from 4 to 5½in., it being generally larger in inside bearings than in outside ones, and the range in length remains as previously stated. We shall have occasion to refer again to inside and outside bearings, when treating of the general principles of construction of the engine frame.

Driving axles which used to be made almost invariably of Yorkshire iron, are now very frequently, and upon some railways exclusively, made of Krupp's, or Bessemer's steel. Mr. Ramsbottom, who makes them, we believe, of Bessemer's steel, does not, on that account, reduce their diameter, but Mr. Sinclair who makes them of Krupp's steel, reduces it by the full amount of one-sixth, at least, of its original diameter, and thus realizes an apparent saving equal to about $\frac{1}{360}$th of the total cost of the engine.

Axle-boxes used to be made exclusively of cast-iron with brass steps fitted into them, as illustrated by Figs. 3 to 8, plate 243. At a later date the driving axle-boxes were frequently made of wrought-iron, as illustrated by Figs. 13, 14, and 15 in the same plate, chiefly with a view to avoid breakages; and on the Continent they are now invariably made of that material; with English engineers, however, it becomes now a general practice to make them wholly of brass, with a wrought-iron strap cast into them, as illustrated by Figs. 9 and 10. This strap is a great safeguard to the sides of the box against the sudden shocks to which they are subjected, and are almost indispensible with underhung springs, when they are expected to carry the whole load upon that journal. Mr. Ramsbottom lines them with Babitt's metal, as most of the other journals and wearing surfaces, and from its use he derives unquestionable benefits. As remarkable instances of the property of this alloy to keep the journals cool during long and rapid journeys, we may instance a journey of the engine "Lady of the Lake," which has been recorded in The Artizan, which conveyed the Irish mail over a distance of 113 miles in 144 minutes without stopping; it may also be stated that another engine of the same class took the same train over a distance of 264 miles without changing.

Breakages across the thinner parts of the sides of the axle-boxes occur very frequently from shocks when there is any play in the journals, or between the sides of the box and the horn plates, and, in order to prevent these, and at the same time to soften the reciprocations of the parts of machinery in motion, Mr. Haslam, of Messrs. Fairbairn and Sons, patented the axle-box, illustrated by Figs. 16 to 19, where an india-rubber lining is interposed between the hard surfaces of the box and the horn plates, that lining acting as a spring; in order to protect the india-rubber against oil, and other causes of deterioration, the horn plates are recessed and the india-rubber compressed into the recess, a wrought-iron plate being placed between it and the axle-box; in leading axle-boxes this plate is wedge shaped, and the box has ¼in. of play on each side of the horn block to enable the axle to adjust itself to the requirements of the road when passing over curves. In a paper read before the Society of Mechanical Engineers, in 1858, it was stated that some axle-boxes fitted up in this manner, which had run as many as 17,000 miles, were still as perfect as when new, and that the definite result ascertained was a diminished wear of the wheel flanges where, in the case of leading wheels the elastic axle-boxes had been used; it was also generally admitted at the meeting that

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the interposition of the indiz-rubber was a decided improvement. Another attempt at improving the construction of axle-boxes with a view to avoiding rapid wear is the one illustrated by Figs. 11 and 12, lately applied by Mr. Sinclair to some tenders for express engines, we believe by way of experiment; here the journal rests upon a series of brass rollers, disposed around the circumference of the journal, and when the carriage is set in motion, it is expected that these rollers will revolve upon their own centres, and that the loss of power and wear of the working faces will be that only due to rolling friction; the centres of the rollers are made of steel, and rest in steel rings, though in reality they have not to carry any pressure, since that is transmitted from the axle-box to the journal, through the body of the rollers directly; we understand, however, that these boxes have already been replaced by common ones.

Horn plates are generally made of cast-iron, rivetted or bolted to the body of the frame, and are made as broad as circumstances will permit, in order to get as large a wearing surface as possible; longitudinally they should form a good fit with the axle-boxes, but sideways there should be a little play, in order to enable the wheels to adjust themselves more easily to the inequalities of the road. Mr. M'Connell, in his later practice, used to forge the horn plates solid with the frame, and thus made a very good and substantial job for strength and durability, although at the same time it was very expensive. Mr. Ramsbottom makes them of Bessemer's cast steel, in the shape of a horse shoe, fitting round the whole of the frame fork; this in the present condition of the manufacture of steel is cheaper than the method previously mentioned, and is probably more durable.

Wheels for locomotives and tenders have for many years been made of wrought-iron, both in this country and abroad, on account of their great elasticity, which is conducive alike to the preservation of the parts of the engine, and of the permanent way; the spokes are from 10½in. to 12in. distant at the rim of the wheel; their thickness varies from 1¼in. to 1½in. and their width from 3½in. to 4½in. Wheel tyres used to be made invariably of Yorkshire iron, shrunk on the wheel and fixed in addition by means of a few rivets, with a view chiefly to prevent the tyre coming loose when worn down so thin, as to roll itself out during performance of its work. Now, however, they are made very frequently of Krupp's steel, which is less liable to wear, and causes the tyres to preserve their original shape during a greater period of time.

It occasionally happens, and especially so in steel tyres, that they break when in use, and that a piece flies off, impelled by the centrifugal force generated by the rotary motion of the wheel; this circumstance has been the cause of serious accidents, and in order to prevent them, some engineers have thought it advisable to fasten the tyres in such manner as effectually to prevent portions of them flying off in the manner stated. Figs. 1 and 2, show two different contrivances to effect this; the one by Beattie with clips placed between each pair of spokes, and a continuous dovetail on the outside of the wheel; the other by Burke, in which the tyre is dovetailed all round both inside and outside; this latter is in our opinion, the most extravagant piece of work that has ever been proposed from the earliest days of locomotive engineering to the present time.

We have already had occasion to make mention of the springs in the course of our introductory remarks on the stability of the engine, and as the analysis of the duties to be performed by them forms an integral part of the general problem of stability, we shall here proceed upon that analysis and, incidentally, give an exposition of the theory upon which their construction should rest, and endeavour at the same time to lay down practical rules to define their proportions.

The beneficial results of the interposition of springs between the load and the axle, or the wheels in all vehicles of what kind soever, are so universally appreciated that it is scarcely necessary to make mention of them. They tend both to the preservation of the road and of the vehicle itself, while as regards the freight, they render land carriage far more agreeable to man, and make it less hazardous, or injurious, to many descriptions of perishable or fragile goods. A fact much less apparent is the one ascertained by General Morin, that the interposition of springs considerably diminishes the resistance to traction. Thus we find it stated in the record of his valuable experiments on traction upon common roads, that at a speed of nine miles per hour, suitable springs diminish the resistance by one-half; and we find also that experiments made upon two waggons exactly similar in all other respects, the one being with and the other without springs, showed that the wear of the road, as well as the increase of resistance to traction, was sensibly the same after the passage of 4577 tons over *the same track*, for the carriage without springs going at a pace of from 2·237 to 2·686 miles per hour, and for that with springs going at a trot of from 7·158 to 8·053 miles per hour. If the reader here does call to mind the facts elucidated in our paper on train resistances, where it was shown that these latter increase in a certain ratio with the speed, he will not fail to appreciate the importance of the interposition, and of the proper arrangement and construction of the springs, in their relation to the economy of railway engineering in general, and of locomotive engineering in particular.

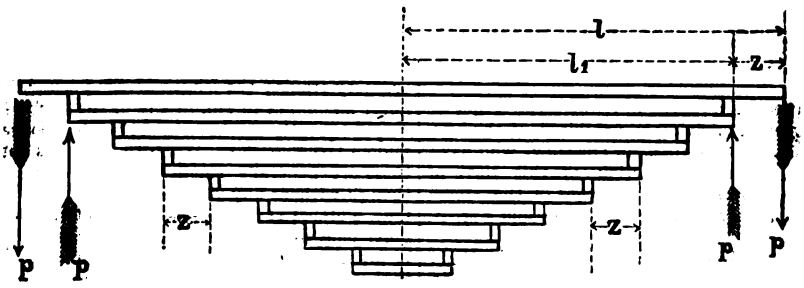

Fig. 9.

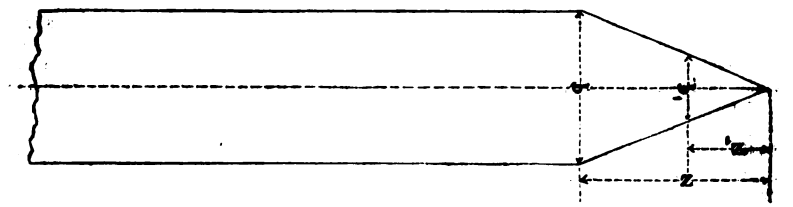

Fig. 10.

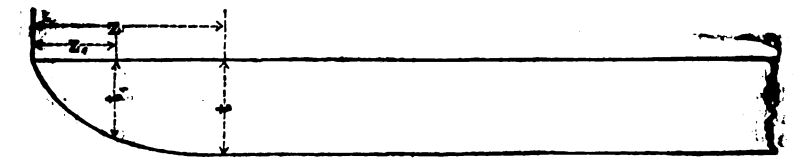

Fig. 11.

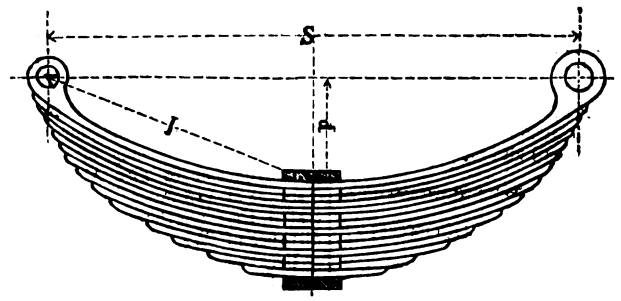

Fig. 12.

As affecting the stability of the engine in progress upon the road, the leading springs should be sufficiently stiff to absorb rapidly the rolling motion caused by the component upward pressure of the steam; compared with the other springs they are subject to the greatest fatigue, because upon them must be wasted all the irregularities of motion arising from the labour of leading the engine, in the performance of which labour there should be the least possible pendulous motion to the front, in order to save the frames from being twisted, and to keep the axle bearings true. Their flexibility is not to exceed $\frac{5}{16}$th of an inch per ton load, unless the wheels are well forward, in which case this limit may be slightly exceeded. In uncoupled engines the driving springs should have great elasticity, or in other words, a great range of deflection, to enable the wheels to follow the rails freely, and to maintain the tractive load as equal as possible; for the same reasons also should the trailing springs be very flexible to

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give way to the driving springs, while the great elasticity in them is also a boon to the engine driver. Driving and trailing springs in uncoupled engines have an elasticity of from ¼in. to ½in. per ton. In six wheel coupled engines. drawing heavy loads and running at low speeds, the elasticity of the springs is limited to about $\frac{5}{16}$ of an inch per ton load, and in engines having all the wheels under the boiler, the trailing springs have an elasticity of ¼ of an inch only to avoid as much as possible the pitching motion spoked of at the beginning of this part of the subject. Mr. Clark, upon entering into the question of constuction of springs, says that "the whole subject is in the hands of empiricists, who work by thumb and by rote," and in this we are inclined to agree with him, though we are constrained to limit that assertion to *some* engineers only. As for Mr. Clark himself, he no doubt has some correct ideas about the laws of deflection and strength of springs, but when he says that "the outer contour of the spring should be as nearly as practicable a parabolic outline when the spring is flat, in order to secure uniformity of strength," he evidently is working by rote also, and had he looked more closely into the subject, or consulted the writings of such as are known to discard empiricism, he would have know that the law laid down by himself, as to the outer contour, is totally erroneous; there are, indeed, many locomotive engineers who labour under that delusion, but we know also that there others, among whom we may mention Mr. Ramsbottom, who construct their springs more in accordance with the theory which we are now about to develope, the correctness of which, we think, cannot be impeached. Let the adjoining sketch (Fig. 9) represent a series of plates resting upon one another by means of narrow distance plates resting upon one another by means of distance blocks; the plates are all of the same thickness and of the same width throughout, but they vary in length in such manner. If the difference be a constant quantity, and if n be the number of plates, we shall have $n\,z = l$; if certain pressures p be applied to the ends of the upper plates they will transmit themselves unchanged to all succeding plates, each of which will be subjected to two couples placed symmetrically on each side of the axis A. B., and the condition of equilibrium is expressed by the general equation.

$$\frac{E\,b\,t^3}{12\,\rho} = p\,(l - x) - p\,(l_1 - x) = p\,z \quad \ldots\ldots\ldots\ldots \quad (1)$$

in which equation E represents the modulus of elasticity of the plates, b their breadth, t their thickness, ρ the radius of curvature of the element of the plate under consideration, and x the distance of that element from the axis A, B subject to the condition that x be smaller than l_1; from equation (1) we readily deduce the following:—

$$\frac{E\,b\,t^3}{12\,p\,z} = \rho \quad \ldots\ldots\ldots\ldots \quad (2)$$

and owing to the condition that p and z are constant, these two equations teach us, first, that the molecular stress, or, as it is termed, the moment of elasticity, is constant throughout the length of the plates; secondly, that, within the same limits, the radius of curvature is constant, or, in other words, that the plates bend according to an arc of circumference. If, however, in equation (1) x be made larger than l_1, then the general equation of equilibrium reads thus—

$$\frac{E\,b\,t^3}{12\,\rho} = p\,(l - x) \quad \ldots\ldots\ldots\ldots \quad (3)$$

and indicates that the radius of curvature decreases in proportion as the point x shifts from the point of support towards the end of the plate; the condition of preserving the radius of curvature unchanged, however, may be realised in two ways—first, by giving the projecting portion of the plate a triangular shape as per sketch (Fig. 10) in such manner as to have always

$$b_1 = \frac{b\,Z_1}{Z}$$

or by reducing its thickness, as per sketch (Fig, 11), in such manner as to have always

$$t^3{}_1 = t^3\,\frac{Z_1}{Z}$$

for in the first instance equation (3) becomes

$$p\,z_1 = \frac{E\,\frac{b\,Z_1}{Z}\,t^3}{12\,\rho}$$

whence

$$\rho = \frac{E\,b\,t^3}{12\,p\,Z}$$

and in the second case it becomes

$$p\,z_1 = \frac{E\,b\,\frac{t^3\,Z_1}{Z}}{12\,\rho}$$

whence again

$$\rho = \frac{E\,b\,t^3}{12\,p\,Z}$$

for any value of Z_1, and at the same time the condition of equal strength is exactly realised in the first case, and in the second case the plate is slightly stronger than a solid of equal resistance.

Let us now apply these considerations to an ordinary curved spring whose plates are bent to an arc of circumference, as per adjoining cut (Fig. 12), where l is nearly equal to the half length of the plate, and

$$l^2 = 2\,S\,d \text{ or } d = \frac{l^2}{2\,\rho} \quad \ldots\ldots\ldots\ldots \quad (4)$$

ρ being the radius of curvature; but according to what has been said

$$\rho = \frac{E\,b\,t^3}{12\,p\,Z}$$

and if we substitute this value of ρ in equation (4), we find for d the following value—

$$d = \frac{l^2\,6\,p\,Z}{E\,b\,t^3}$$

and if at the same time we remember that $l = n\,Z$, we obtain finally

$$d = \frac{6\,p\,l^3}{n\,E\,b\,t^3} \quad \ldots\ldots\ldots\ldots \quad (5)$$

From this equation we may calculate the deflection under a given load p, but it is not sufficient to enable us to construct the spring, for we do not yet know what thickness and what number of plates are required to enable it to carry that load with safety; this will be realised if it is constructed in such manner as to satisfy to the condition expressed in the following equation—

$$p\,Z = \frac{R\,b\,t^2}{6}$$

where R stands for the strain per square inch, with which the metal may safely be loaded; but as we have also the relation

$$Z = \frac{l}{n}$$

we obtain finally for the condition of safety

$$p = \frac{R\,n\,b\,t^2}{6\,l} \quad \ldots\ldots\ldots\ldots \quad (6)$$

and if this value of p be introduced into equation (5), we shall define the maximum deflection which the spring may take with safety, as follows:—

$$D = \frac{R\,l^2}{E\,t} \quad \ldots\ldots\ldots\ldots \quad (7)$$

So far we have dealt with one half of the spring only, but for practical purposes it will be more convenient to introduce the total load and span into the above formulæ, which, if S be the span, w any assumed load not exeeeding the limit of elasticity, and W the whole working lead which the spring shall carry, will be modified, as follows:—

For deflection under given load,

$$d = \tfrac{3}{8}\,\frac{w\,S^3}{n\,E\,b\,t^3} \quad \ldots\ldots\ldots\ldots \quad (8)$$

For the safe working load,

$$W = \tfrac{3}{8}\,\frac{n\,R\,b\,t^2}{S} \quad \ldots\ldots\ldots\ldots \quad (9)$$

And for maximum deflection consistent with safety,

$$D = \tfrac{1}{4}\,\frac{R\,.\,S^2}{E\,t} \quad \ldots\ldots\ldots\ldots \quad (10)$$

which formulæ will enable the student to construct springs for any given load and circumstances, provided we supply him with the numerical values of E and R. These values as accepted for the general purposes of engi-

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Description of spring.	Deflections in inches for loads in cwts. 45	50	70	90	110	130	150	Value of R in tons per sq. inch.	Value of E in tons per sq. inch.
Working load, 6 tons 5 cwt. 21 plates, 4½in. by ⅜in.	ins. $\frac{1}{2}$	ins. $\frac{9}{16}$	ins. $\frac{13}{16}$	ins. 1⅛	ins. 1⅜	ins. 1¹¹/₁₆	ins. 1¹⁵/₁₆	tons. 25·5	tons. 11287
Working load, 4 tons 15 cwt. 16 plates, 4½in. by ⅜in.	¼	⅝	1	1¼	1⅝	2	…	25	13890
Working load, 2 tons 16 cwt. 12 plates, 4in. by ⅜in.	⅜	7/16	¾	…	…	…	…	18·4	12189
Working load, 5 tons 8 cwt. 21 plates, 3in. by ⅜in.	½	9/16	⅞	full 1⅛	bare 1 9/16	full 1⅝	…	32·6	16210
Working load, 5 tons. 20 plates, 3½in. by ⅜in.	1⅛	1⅜	2⅛	2⅞	bare 3⅜	bare 4⅜	5⅛	34·4	12366
Working load, 4 tons. 20 plates, 3½in. by ⅜in.	1⅛	1 5/16	2	2 11/16	bare 3⅜	4	…	27·5	13668
Working load, 5 tons 2 cwt. 19 plates, 3½in. by ⅜in.	5/16	3/8	9/16	bare ¾	1⅝	1¼	…	24·2	13753
Working load, 3 tons 16 cwt. 12 plates, 4in. by ⅜in.	5/16	3/8	9/16	full ¾	1	1⅜	…	13·8	15020

Description of spring.	Deflections in inches for loads in cwts. 45	50	70	90	110	130	150	Value of R in tons per sq. inch.	Value of E in tons per sq. inch.
Working load, 4 tons 18 cwt. 16 plates, 4in. by ⅜in.	ins. ⅜	ins. 7/16	ins. 11/16	ins. full ⅞	ins. full 1⅛	ins. 1⅜	ins. …	tons. 24	tons. 11410
Working load, 2 tons 10 cwt. 11 plates, 2¼in. by ⅜in.	¼	⅞	1⅜	…	…	…	…	29·6	23497
Working load, 6 tons 5 cwt. 21 plates, 3½in. by ⅜in.	5/16	¼	full 7/16	full 9/16	bare 1⅜	1⅝	1⅛	27·3	13738
Working load, 4 tons 14 cwt. 16 plates, 4in. by ⅜in.	⅜	½	11/16	⅞	1 1/16	…	…	21·8	12194
Working load, 4 tons 10 cwt. 19 plates, 4in. by ⅜in.	9/16	bare 1 1/16	1 5/16	1 5/16	1⅝	2	…	22·1	12092
Working load, 4 tons. 18 plates, 4in. by ⅜in.	9/16	⅝	1	1 5/16	1⅝	2	…	21	12343
Working load, 2 tons. 10 plates, 4in. by ⅜in.	1	1 1/16	1 1/16	2 5/16	…	…	…	19·2	14827
Working load, 6 tons 15 cwt. 19 plates, 6in. by ¼in.	7/16	¼	bare ⅜	½	full ⅝	13/16	1	12	19830

Mean values of R and E..... 23·6 14280

Received value of E from 11,200 to 17,850 tons per square inch.

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neering may be found in various works on practical mechanics, but the reader will at once perceive that these may scarcely be expected to apply to the present case, where the elasticity of the spring as manifested by its deflection may be much affected by the mode of connection and superposition of the plates, and where the peculiar circumstances under which it is called upon to do its work, must have a great influence in the assumption of the unit strain. Here again, therefore, we think we cannot do better than turn to actual practice to supply this want, and on the preceding page we give a table of springs as made by Messrs. Sharp, Stewart, and Co. for various descriptions of engines, with their working load attached to each of them, and an abstract of tests made to ascertain the deflection under a gradually increasing weight. The working loads in conjunction with the other particulars of the springs will enable us to find a practical value for R, and the deflections with their corresponding loads will enable us to find a practical value for E.

Upon inspection of this table it will be perceived that in each individual case the elasticity of the spring remains constant for equal additions to the load throughout the range of the tests which have been carried to a point far beyond the actual load of the spring. The value of the co-efficient of elasticity, E, as calculated by means of formula (8) for each spring remains within the limits generally assumed for that factor, with the exception only of two cases, in both of which it exceeds the maximum limit, as we indeed at the outset anticipated it should do, owing to the frictional resistance to bending from closeness of connection of the plates; in both cases, however, the construction of the spring is of somewhat exceptional character, yet, notwithstanding these irregularities, for the 16 cases the mean value of E is very nearly an arithmetical mean between the upper and the lower limits of the value assigned to it by Dr Rankine. The value of R, or the unit stress under the working load at rest, is somewhat considerable, ranging from 12 to 34·4 tons, and for the 16 cases, averaging 23·6 tons, and if an arithmetical mean be taken between these and the mean working load divided into it, the factor of safety will be found equal to 2 exactly. As there are no indications, however, that the elasticity of the metal has sustained any injury, though the tests have been carried much beyond the working load, and as the cases recorded in the table above, embody not only the experience of Messrs. Sharp, Stewart, and Co., but also that of various engineers both at home and abroad, the mean value of R, which we have found, may, with confidence, be taken as a sufficient amount of safety for the particular case of locomotive springs here under consideration. If these mean values of E and R be introduced into formulæ (8), (9), and (10), these may be put into the following shape, viz :—

For the deflection under a given load,

$$d = \frac{1}{38080} \cdot \frac{w\,S^3}{n\,b\,t^3} \quad \ldots\ldots (8a)$$

For the safe working load,

$$W = 16.4\,\frac{n\,b\,t^2}{S} \quad \ldots\ldots (9a)$$

And for the maximum safe deflection,

$$D = \frac{1}{2420} \cdot \frac{S^2}{t} \quad \ldots\ldots (10a)$$

where w and W are expressed in tons, and S, b, t, d, and D, in inches and fractions of inches.

To facilitate comparison with Mr. Clark's formulæ, which we have transcribed below, we have modified the notations in the preceding formulæ, giving. like Mr. Clark, the deflection d, and the thickness t, in sixteenths of inches, S and b remaining as before :—

$$d_1 = 1{\cdot}72\,\frac{w\,S^3}{n\,b\,t_1^3} \quad \ldots\ldots (8b)$$

$$W = \frac{1}{15{\cdot}6} \cdot \frac{n\,b\,t_1^2}{S} \quad \ldots\ldots (9b)$$

$$d_1 = 1{\cdot}66\,\frac{w\,S^3}{n\,b\,t_1^3} \quad \ldots\ldots \text{(Clark)}$$

$$W = \frac{1}{11{\cdot}3} \cdot \frac{n\,b t_1^2}{S} \quad \ldots\ldots \text{(Clark)}$$

The great analogy between these formulæ shows that we were quite justified in saying that Mr. Clark had some correct ideas about springs, and though his numerical co-efficients have been obtained by a process widely different from our own, yet must they have been nearly identical with those found by ourselves, had he based his calculations upon a number of different examples instead of one only.

From a careful study of the theoretical considerations which form the earlier portion of this part of our subject, the reader will perceive also that the contour of the spring has nothing in common with the parabola, but that, in order to realise the condition of practically perfect elasticity and equal strength, the contour of the spring when it is under its maximum deflection, should be as near as possible such, that the projection of each plate over the one immediately underneath it be equal throughout the length of the spring. This condition is decidedly aimed at in Mr. Ramsbottom's springs.

Springs which are intended to have much elasticity should be with considerable camber, so that they may expand as they receive their load, and the increased stiffness from friction of the plates be compensated by the increase of span. Upon looking over the preceding table it will be found that the springs which have the greatest elasticity have an original camber of from one-seventh to one-tenth the span. The plates of springs are held together by means of a buckle shrunk on in the centre, and at the ends they have generally studs punched on them, which are made to fit into corresponding slots in the contiguous plate; this, however, is unquestionably a source of weakness to the spring, and we believe Mr. Ramsbottom has dispensed with the slots altogether, and simply stamps nips upon the ends of the plates in such manner as to cause them to fit into each other. This is, we consider, decidedly the more preferable plan.

(To be continued.)

THE RUSSIAN IRON-CASED BATTERY "PERVENETZ."

We have given in another column an account of the launch of the iron-cased battery *Pervenetz*, built by the Thames Ironworks and Shipbuilding Company for the Russian Government, together with some other particulars as to the dimensions and characteristic features of that vessel. For the further information of our readers, we insert the accompanying illustrations (given in the next page) and additional remarks :—

Fig. 1 is a longitudinal outline elevational view showing the rig of the vessel general contour of the hull.

Fig. 2 is a half midship section to an enlarged scale.

Fig. 3 is a horizontal section of a portion of the hull amidships, shewing two of the port-holes, the distance between the centre of which is 12ft. 8in.

The height of the bottom of port-hole from the water-line is 7ft.

The height between the top of the lower deck to underside of main deck is 6ft. 10in.

The keel of the *Pervenetz* was laid in April, 1862. The dimensions, &c., having been previously determined upon between the Thames Ironworks Company and the Russian Government, the Company proposed designs which were submitted to, and approved by the Russian Government.

The *Pervenetz* is intended for shallow-water operations in the Baltic, and the peculiarity of her construction renders her specially adapted for this purpose. Her armour plating is 4½in. thick amidships, and 3in. at the ends. The total weight of armour is about 600 tons; the teak backing behind the armour is 10in. thick, worked horizontally. It will be seen, on reference to Fig. 1, that the two ends are of very peculiar shape, which occasioned some considerable difficulty in adapting the armour plating to these parts. The stem is about 3ft. 6in. broad at the water-line, and gradually assumes the form of the flat keel plates at the heel. To the stem is attached the bulkhead running longitudinally as far aft as the foremost engine-room bulkhead, the object of this bulkhead being to give to the stem the necessary strength to withstand concussion in the event of the prow being used as a ram; which, however, is not very likely to be the case, as the vessel is not supposed to steam more than 8 or 9 knots an hour. The stern frame from its peculiarity and novelty is also deserving of notice, and considerable ingenuity has been exercised in the method arrived at by Mr. Macrow,—the naval constructor of the Thames Iron Works and Shipbuilding Company,—of applying the steering apparatus, as the rudder frame being at the extremity of the ship, there is not breadth at that part to give more than about 25 degrees of angle; and in consequence of the foremost post running up to reach the upper part of saddle, there was not sufficient length of tiller. This necessitated the transferring of the centre of the rudder-head to another centre before the foremost post, by means of two strong wheels and an endless chain, so as to get an angle of 42° or more if required. This arrangement will be better understood upon reference to the accompany sketches, Figs 4 and 5; *a* being the rudder, *b* and b^1 the two wheels, *c* the tiller, c^1 the endless chain, *d* the central line of the propeller shaft, *e* is the iron deck at water-line, *f* is the main deck, *g* the 3in. armour plating, and *h* the teak backing.

It was originally intended that the engines of the *Pervenetz* should be of 400 nominal horse-power, but it was afterwards decided that 300 would be sufficient, and would effect a saving of some few inches in the draught. We may add that the Russian Government are themselves building in Russia a similar vessel to the *Pervenetz*..

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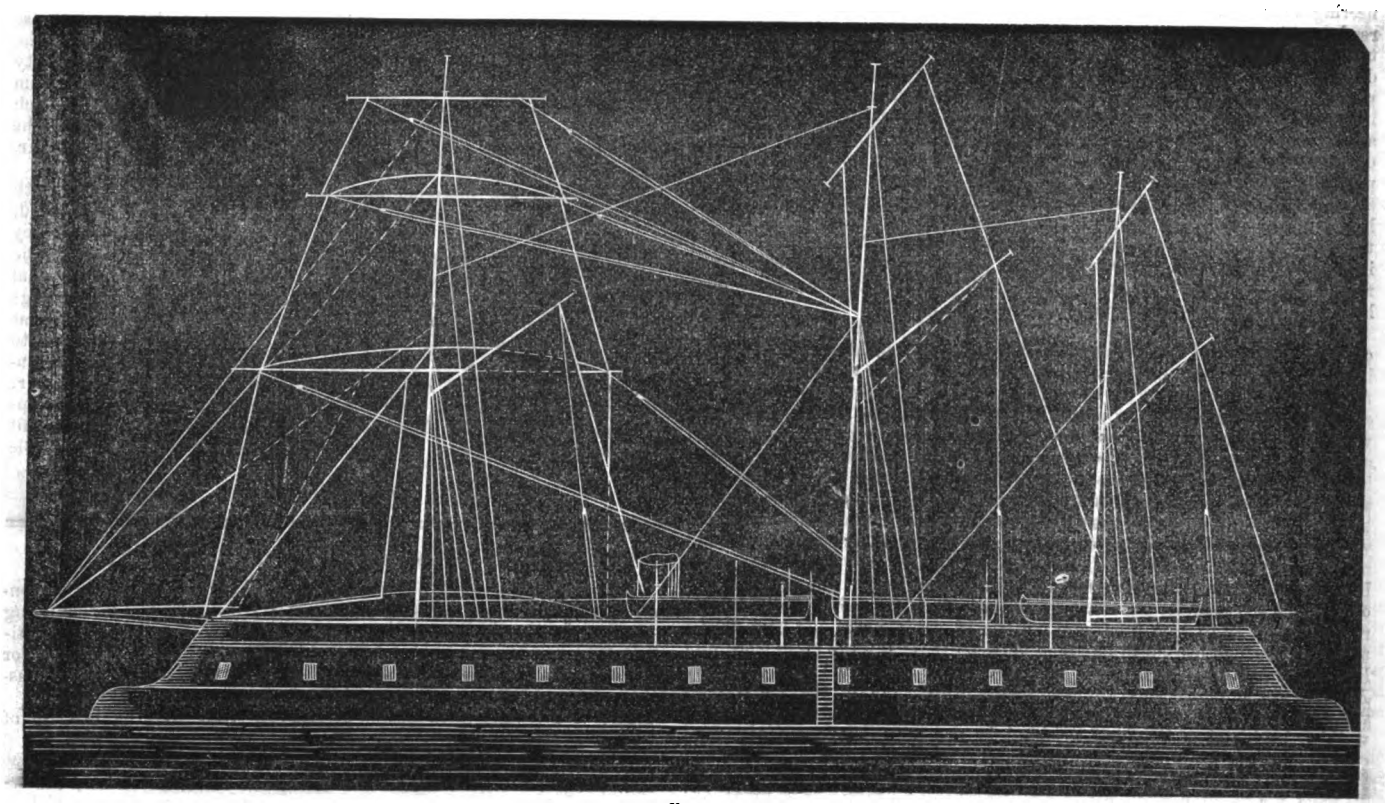

Fig. 1.

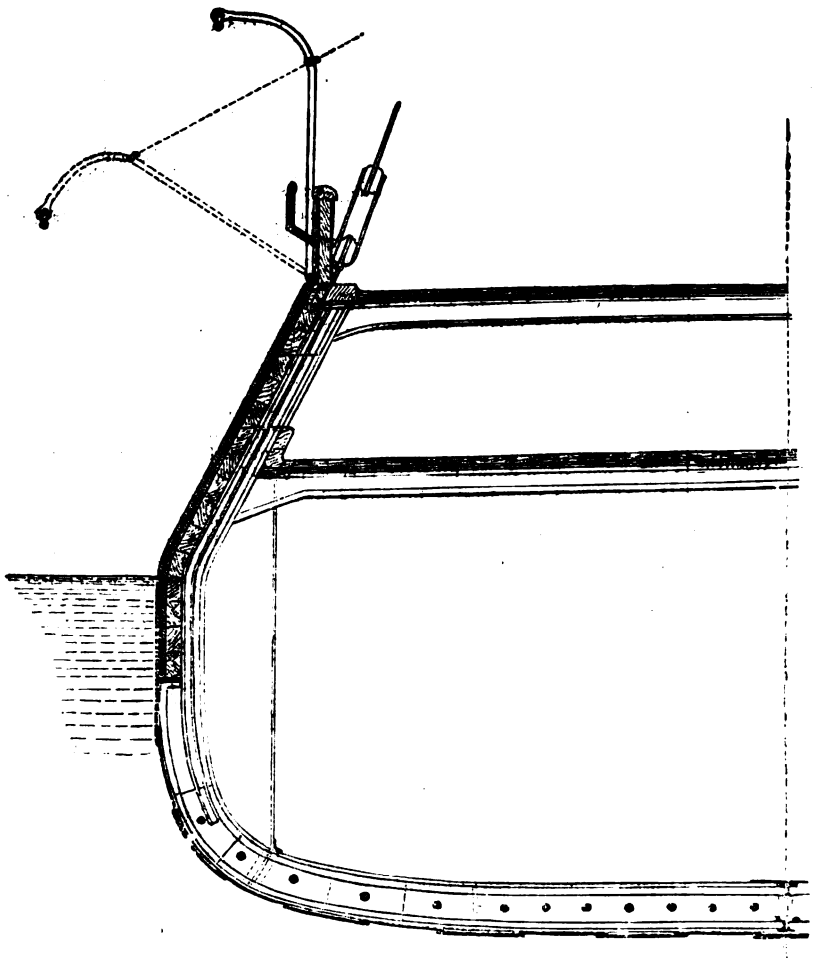

Fig. 2.

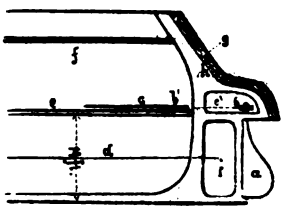

Fig. 4.

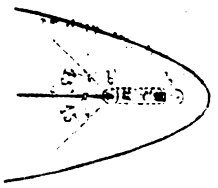

Fig. 5.

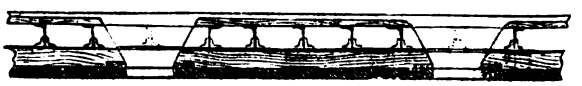

Fig. 3.

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INSTITUTION OF MECHANICAL ENGINEERS.

ON THE CONSTRUCTION AND APPLICATION OF IRON ARMOUR FOR SHIPS OF WAR.

By Mr. Norman S. Russell.

The problem of forming an iron fleet would at first sight seem a simple matter; for starting with the following facts proved by experiment—first, that 1in. thickness of iron breaks up shells so as to prevent their explosion as shells; secondly, that 2½in. thickness of iron stops them completely, and prevents the fragments of the broken shell from being carried through the ship's side like grape; and thirdly, that 4½in. thickness stops the heaviest shot fired from the most powerful guns which the science and manufacturing skill of this country have hitherto produced—it is only necessary that the vessels of the present wooden fleet, as they already exist, with engines on board, should be coated with the heaviest of these three thicknesses of iron which each ship is able to carry, and an iron-plated fleet will then be obtained. It is true that this immense fleet will cost more than a new and effective one of equal power; that not one of these vessels would be able to cross the Atlantic; that the entire fleet could not prevent a single fast cruiser from seizing all the gold ships on their way from Australia; and that they would not effectively blockade the coasts of any foreign power with whom there might be war; our supremacy at sea would be gone, but we should be safe from invasion, and able to stop an enemy attempting to land here.

This problem has already been tested with regard to the iron-coated French and English batteries. Several of them were built by this country and sent on their way to the Crimea; but after several disasters, and going as fast as they could under steam and sail, they got only half way, and returned to this country having done nothing; in short they were not sea boats. Such an iron-plated wooden fleet would be of a little more value than local batteries on shore, but only a very little; they could shift their position it is true, and provided it was known where an enemy intended to land, they could prevent his landing; but their advantage in this respect over land batteries would hardly compensate for their superior cost.

If it is desired to retain our supremacy at sea, a fleet must be formed that can not only fight a battle, but also ensure winning it. Such a fleet must be designed and constructed anew from the beginning; whether it shall be constructed entirely of iron or with wood backing to support the armour plates is still an open question; but in order to possess all the good qualities which are required in naval warfare, there can be no doubt that the structure of the vessels must be of iron. The real difficulty of the problem consists in this, that any existing ship of war when iron-coated will be slow, unseaworthy and combustible, and will be incapable of long voyages; whereas the fleet of England must be able to keep at sea for a long time, to steam long distances, to go faster than the ships of any other country, and to be in better condition than other fighting vessels in all weather, especially the worst. The whole difficulty consists in designing vessels possessing all these qualities in addition to being shot-proof.

To begin the consideration of an iron shot-proof fleet, by taking an example of a vessel which it would be wished to construct if possible; the question arises, can shot-proof gun boats, such as have hitherto been built be now built 140ft. long, 24ft. beam, of 80-horse power, and carrying 4 guns; and the answer is, they cannot be built, because the weight of iron would sink them. Even an iron-plated corvette of a favourite class, 190ft. long, 36ft. beam, and drawing 16ft. of water, propelled by 250 horse power engines, could not be constructed. In short, to carry a high side out of the water, the ship cannot be much less than 60ft. beam; and to go with the requisite speed it must have a length of about 400ft.; it would then be a completely shot-proof iron ship worthy of the British fleet, but even this vessel would be 7000 tons burden. Smaller vessels can of course be built, but if they are to have good qualities, and are intended to act in concert with the more powerful vessels, they must be only partially coated and will be compromises.

The first ship of this class will be like the *Warrior*, shown in the accompanying illustration, Fig. 1; the next will be a smaller vessel with only the engines, boilers, and magazine protected; and the last will be a small shallow-water gun-boat, with one gun protected by a shield in front. But as far as a sea going fleet is concerned, the engines, boilers, and magazine must be protected; and it is this indispensable requirement which makes an effective ship of war really a very large one. It seems to be agreed that 14 knots an hour is the minimum speed of fighting vessels of war for the future; but this speed cannot be got in a vessel under 200ft. long, and for that purpose the lines must be very fine. In order to carry the engines and boilers, which must be protected, the ship must be 60ft. longer; and in order to carry also a coated battery of 10 guns it will have to be 40ft. beam; and even then the vessel is only partially coated.

It will thus be seen that the large size of vessels which are to be entirely coated, and the mere partial coating of smaller vessels, are equally inevitable. Both are the results of unalterable laws, in the adoption of which there is no choice. This point has to be insisted upon the more strongly, because the question has sometimes been considered as if both the size of vessels and the extent and nature of their armour were matters of free choice. Such vessels are inevitably of enormous cost, and therefore too much pains cannot be bestowed on their mechanical design and the strue ture and durability of their armour.

The consideration of armour resolves itself into three principal questicns first, what is the best kind of armour merely to resist the impact of shot for which purpose the armour may be considered to be simply hung on the side of the ship, in no way contributing to the strength of the structure but merely as dead weight hanging on the hull. Secondly, what is the best way of forming the structure of a ship entirely of iron, with a view of employing the whole strength of the iron for the purpose of rendering the structure of the ship as strong as possible; making the vessel only so far shot-proof as the nature of the structure will admit, and considering resistance to shot a secondary object. In the first of these methods armour plates are hung on an already finished ship; in the second a ship is built up of thin plates in such a way that these plates may afford as much protection as their weight can give. It remains to be considered, however, thirdly, whether the thick armour plates and the thin ship plates could not be so combined together in the structure of a ship as to give thac ship all the benefit of them both as armour plates and as integral parts of the strength of the ship.

The first of these questions is easily disposed of. In the original floating batteries of 1854 an ordinary wooden hull of a ship was covered with iron plates weighing about 3 tons each and 4in. thick, tacked on by through bolts of 1¼in. diameter, slightly coned and countersunk on the outside with nuts on the inside, perforating of course the sides of the vessel. It is in this simple and rude manner that the six vessels now building by the Admiralty are coated over, with 4½ and 5½in. armour plates. The armour of the French wooden vessels is also fixed in this manner, except that wood-screws have been substituted for through bolts and nuts, as shown in Fig. 2, which represents a section of the armour of *La Gloire*, the first constructed of the armour-plated ships.

The *Warrior*, the first English armour-plated ship, is also coated on this principle, as shown in Fig. 3, which is not affected by the circumstance of this vessel having an iron skin.

The first reliable experiments made in this country on armour plates were those against the side of the *Trusty*, in 1859, of which Admiral Halsted has left a valuable record. The armour, shown in Fig. 4, consisted of 4in. iron plates fastened to the side of the vessel, which was equal in scantling to that of a 90 gun ship. The general result of these experiments was that out of more than 25 shots, fired from Armstrong, Whitworth, and ordinary 32 pounder guns, only two shots pierced the armour at the joints of the plates, and these were then so spent that they dropped on the deck of the ship without reaching the other side. It is not known that any experiments were made on the armour of *La Gloire*; no doubt the actual experience gained from the iron-coated floating batteries at Kinburn was considered of more value than any which could be obtained from firing against a target under circumstances that could scarcely occur in actual warfare.

The *Warrior* target, Fig. 3, like the plating of *La Gloire*, was based upon the experience goined by the French floating batteries at Kinburn, and ½ inch was added to the thickness of the plates as an allowance for the improvements in artillery, making 4½in. total thickness. The plates were wider, and the iron skin was placed behind, forming the side of the iron *Warrior*. This target was subjected to the fire of the ordinary Armstrong and smooth-bore guns; the plates were driven in from the bolt heads and were bent and buckled in a manner that proved their admirable qualities, but the bolts were not broken, except when struck by shot, and the skin remained intact. This was the great triumph of armour plating, which proved that the iron-coated ships then in existence were invulnerable under circumstances very unlikely to be reached in an actual naval battle. Subsequently experiments were tried with the 156 pounder gun, and the three shots fired at the target punched a clean hole through the armour plate, and lodged in the backing, but did not penetrate the iron skin behind.

In the second method of constructing iron war ships, the best structure of the ship exclusively has been kept in view, and it has been endeavoured by increasing the thickness of the structure to render it shot-proof, without sacrificing any of the materials for that purpose but retaining the use of their whole strength in the ship. This was a very likely course for either an engineer or shipbuilder to follow, and those who took up the subject from a mechanical point of view have more naturally adopted this system which may be called the structural system; while the artillerist took up the former former plan of simple iron armour, neglecting structural considerations. The principal applications of this second system are shown in Figs. 5, 6, and 7.

Experiments on armour plates were made in the United States at the beginning of the present century by Mr. Stevens, the father of the present system of armour-plated ships; and the "Stevens Battery" shown in

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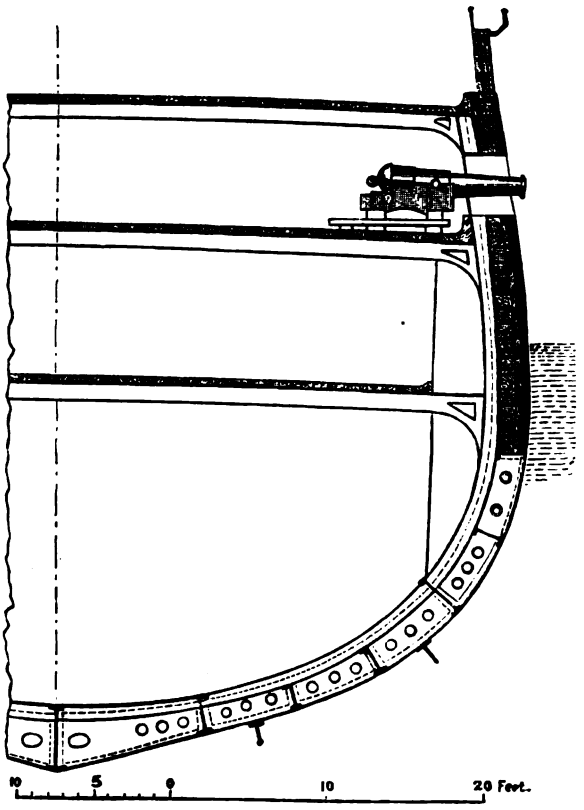

Fig. 1.—Section of Warrior.

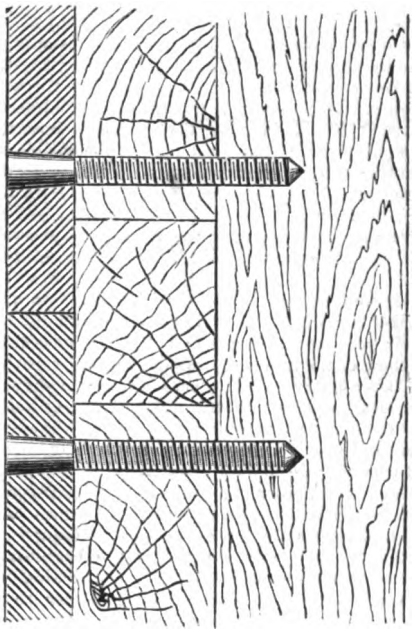

Fig. 2.—La Gloire.

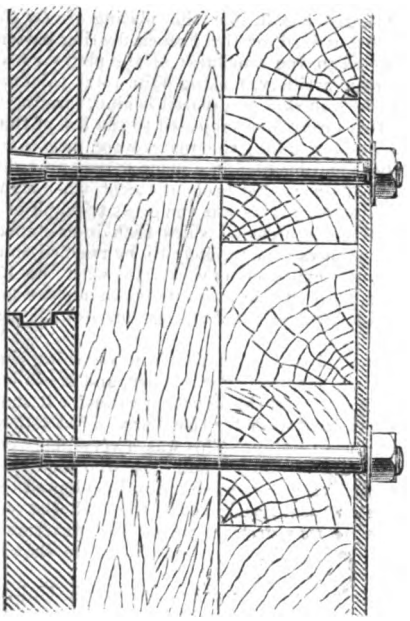

Fig. 3.—Warrior.

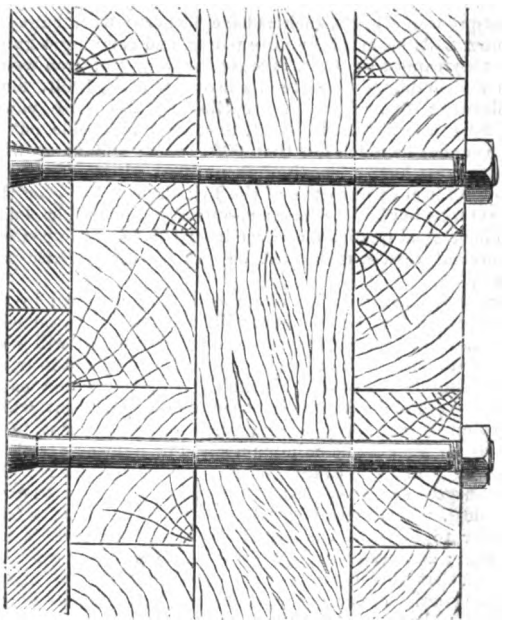

Fig. 4.—Trusty.

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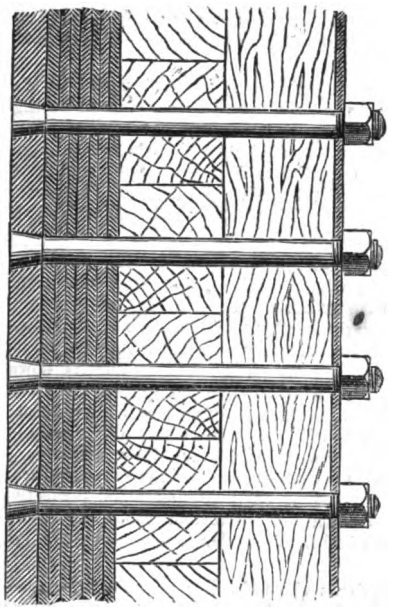

FIG. 5.

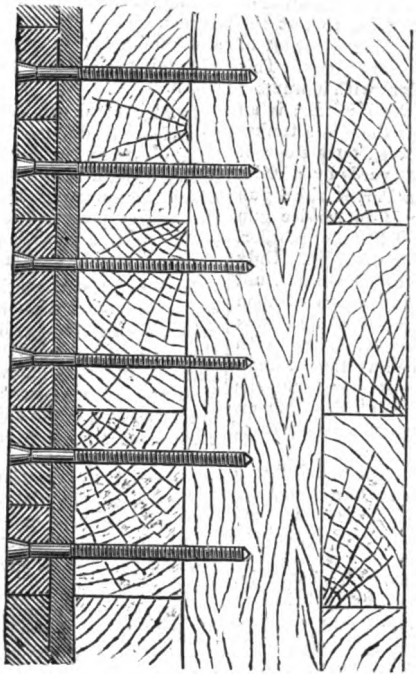

FIG. 6.—MERRIMAC.

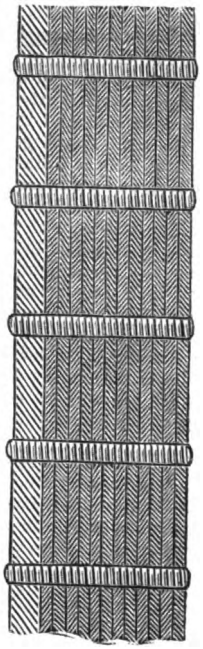

FIG. 7.

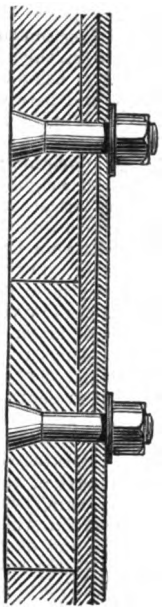

FIG. 8.

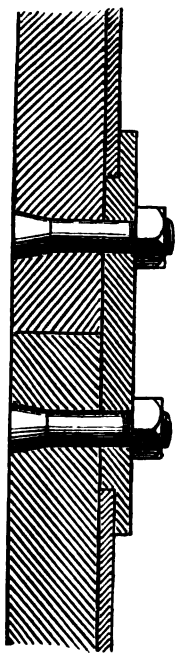

FIG. 9.

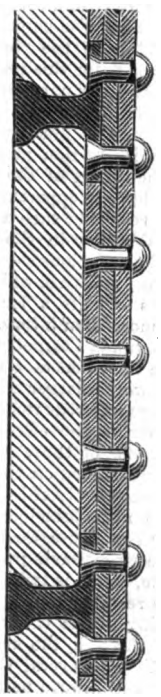

FIG. 10.

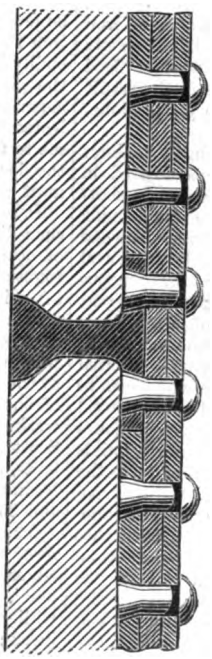

FIG. 11.

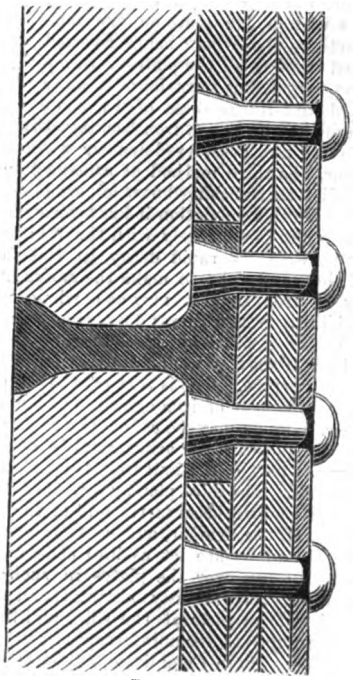

FIG. 12.

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in section at Fig. 5, was constructed at a later period by the American Government in consequence of those experiments. The ship was only half finished when its construction was discontinued; but since the agitation of this question in America several experiments have been tried to test the peculiarities in the construction of this vessel, by subjecting a target of similar construction to the fire of the heaviest American naval guns. This armour is 6¼in. thick in all, being composed of 2-in. plate with a number of ¾in. plates behind it. The Stevens Battery, like the *Warrior*, is an iron ship, and between the iron skin and the armour there is a timber backing of 14in. of locust timber. The target was placed on a slope of 27½° to the horizon, and fired at from a distance of 220 yards by a 10-in. service gun weighing 88 cwts., and subsequently by a Parrot rifled gun of 6½in. bore weighing 86 cwts. The shot from the 10-in. service gun was solid spherical shot weighing 124lbs., with a charge of 11lbs. of powder. The deepest indentation made by this shot in the armour was 1¾in. Only 100lbs. shells were fired from the Parrot gun, with 10lbs. of powder, and they made indentation only 1 inch deep. The slight effect produced upon the Stevens armour must be attributed to the great angle at which it was placed and the low velocity which 124lbs. shot would have when fired with only 11lbs. of power. The Americans, however, still believe that a number of thin plates properly backed are better able to resist shot than one plate of equal thickness, which can only be considered to arise from an inability at present to forge or roll thick soft and homogeneous plates of large dimensions.

The armour of the *Merrimac*, shown in Fig. 6, although it was designed simply for resisting shot, must necessarily, from its peculiar formation, add to the strength of the ship. It was not formed as is generally supposed of railway bars, but in a manner much more effective and ingenious. Bars of iron 6in. wide and 1½in. thick were placed vertically on the side of the ship, and another outer layer of bars of the same width but 2½in. thick crossed the lower layer at right angles, the whole being bolted at each intersection to the side of the ship by ¾in. bolts or screws. This armour seems to have stood remarkably well against the heaviest shot of the ships of war to which it was exposed, but fired at low velocities; for as far as it is known, no shot fired from the *Congress* or the *Monitor* pierced the side. It forms probably the cheapest armour that can possibly be constructed, and has been introduced for fortifications by Captain Inglis, where weight is of no consequence and cost is everything. In the armour for ships of war, however, the case is precisely reversed.

In Fig. 7 is shown a section of the target constructed by Mr. Hawkshaw, who was one of the first to see the important advantages to be derived from the substitution of a structure of thin iron plates in place of the thick armour plate with wood backing, provided an equally effective resistance to shot could be obtained. This target consisted of twelve ¾-in. plates with a 2in. plate on the outside, forming 11in. thickness of iron altogether, the whole being rivetted together or tied by 1½in. screws tapped through all the plates at 8in. pitch. Only a few shots were fired at the target, but the trial of it was a valuable experiment, and the result proved that future ships of war could not be formed of thin plates alone, though the question of iron backing still remained open.

Having now considered armour without strength and strength without armour, the third method of construction comprises the plans devised in the belief that nothing but thick armour plates perfectly solid can be shot-proof. In this conviction it has been attempted to counect the iron armour directly and immediately with the iron hull of a ship, so as to avoid wood backing with its rapid decay, its bad fastening and its bad structural qualities, and so as to make the entire hull and armour one homogeneous mass of iron, that it may as a whole, possess vast strength and great durability. When this is done, the enormous cost of a fleet of large vessels will not be perilled by the chances of premature decay, and the ships will not be burdened by useless loads of material. Three plans have been tried for this purpose. One is that of the Iron Plate Committee who were to try the question of iron against wooden backing. A second plan adopted by Mr. Samuda may be called the thick plate structure, because it takes the thick plates of the armour and by scarfing them from the inside, builds the upper part of the hull from the armour plates, so that they form the ship itself. The third plan by Mr. Scott Russell may be called the incorporation structure, because the hull of the ship is here built up quite independent of the armour, and recesses are prepared in this structure into which the plates are let as into cells, and the edges of the cells are then rivetted down over the plates in such a manner as to incorporate the plates into the previously existing structure; by this plan the backing and fastening form parts of the ship, and the armour plates communicate as much strength as one uninterrupted rivet all round the edge can give them.

The Iron Plate Committee, knowing the advantages to be derived from the substitution of an iron for a wooden backing, designed the iron target, shown in Fig. 8, which in every way except the wood backing was on the same principle as the *Warrior* target. The bolting was the same in principle, and there were ribs at the back; the only difference being that a little less material was put into the skin and a little more into the ribs. The result proved the utter insufficiency of the bolting, since 8 out of the 46 bolts holding on all the armour plates snapped off at the first round. It also proved that an iron target formed in this manner was not an improvement on the *Warrior* target so far as resisting shot was concerned. The target would probably have stood much better if the backing and framing had been exactly the same as in the *Warrior* and had had 2½in. of backing with 10in. frames, instead of only 1in. skin, and ribs of twice that depth.

In Fig. 9 is shown the target next experimented upon, designed by Mr Samuda. It differed from that of the Iron Plate Committee in having 5½in. plates, and having a very different system of framing; the chief peculiarity being a strong thick plate at the edges of the armour, through which the numerous 1¾in. bolts or rivets were fastened. The framing of this target proved inferior to that of the previous one, but the plates curled up in a much less degree, and stood better, excepting at the edges where they were weakened by the bolt holes.

In Fig. 10 is shown the target next tried, constructed on Mr. Scott Russell's plan of continuous rivetting, wholly of iron, and introducing the principle of fastening the plates without bolts. The armour plates of 4½in. thickness, are fitted in between wrought iron bars of the same depth, which run longitudinally and vertically along the ship's side and form part of its structure. These bars are heated at the outer edge and hammered down over the edges of the adjacent armour plates, in such a way as to form one continuous rivet passing all round the edge of each plate. There are several other plans for holding plates without bolts, which differ only in their practical execution from that now described, but their principle is the same, and the trial of this may be considered in effect as a trial of them all. The result of experiments proved that the fastening stood perfectly, and that an iron target could be constructed entirely of iron which could prevent the 156lbs. shot fired with 50lbs. of powder from passing through the armour.

The author then proceeded to submit the following conclusions, viz.:—In the first place a thick plate must be employed on the outside of the target. As much of the armour as practicable should be put into the structure of the ship, but it must have a thick plate on the outside. The plate must not only be a thick one, but it must also be a wide one; in other words the fewer cracks in the armour to begin with the better. The large plates are of course very expensive, and it would be highly satisfactory if smaller ones could be made to do as well; but the 68lb. shot insists upon large armour plates if it is to be kept outside the ship.

The next fact, which is common to armour backed with wood, and armour backed with iron, is that every bolt hole weakens the plate. A large bolt hole does not weaken it more than a small one; and if bolting is found to be the best mode of fastening, the bolts should be large and there should be few of them. The holding of the plate is of more consequence in an iron than in a wooden target, for this reason, that the iron plate is driven bodily into the wood and the only purpose which the fixing serves is to keep the plate from absolutely falling off. It would prove a very instructive experiment and would not cost much to have the *Warrior* itself subjected to the same test as its section at Shoeburyness, and then sent to sea to try the effect of the rolling of the ship upon the loosened plates; the dockyards would also have an opportunity of finding out the easiest and most efficient method of repairing such a iron fleet.

It seems very remarkable that in the construction of armour plating, such different mechanical proportions should have been adopted from those of other iron constructions, and that while 1in. plates would be fastened together with 1¼in. rivets or bolts, a large plate 20ft. long, upwards of 3ft. wide, and weighing more than 5 tons, should be fastened on by only fifteen 2in. bolts. Mr. Samuda's target was far less injured and far less changed in general shape than that of the Iron Plate Committee, for the simple reason that there were a larger number of bolts to hold the plate to the skin; but they were unfortunately so close together that a couple of shots happening to strike the edges of the plates where they were weakened by the holes, one of the shots went clean through. In Mr. Scott Russell's target, constructed on the principle of fastening without bolts, the face of the target was less disturbed. The area of fastening or bolting to a given plate on this principle is 12 times that of Mr. Samuda's and 25 times that of the Iron Plate Committee's target.

The effect of shot on a target having wooden backing is to expend all its force on the armour plate, which is twisted and bent and curled up at the edges, but the iron skin remains intact. In the iron target, on the other hand, the skin and backing divide the work with the armour plate, and while the skin is broken through, the armour plate remains but little injured; and probably, although several shots did go through the two iron targets, if the firing were continued on them as well as on the *Warrior* target, the latter would be smashed in long before either of the former.

Whenever, therefore, ships come to be built entirely of iron, as will be the case at some future time if not now, it is submitted that they must have the following qualities: the armour plates must be wide, there must be no bolts, the fastenings must be large, and there must be an inner skin to prevent the pieces of iron from flying among the crew. Such an armour

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will then be superior in resisting power to that of the *Warrior*, adding to the strength of the ship instead of detracting from it, having a skin uninjured and independent of the armour; and it will cost nothing for repair, but will last for ever.

It is important to glance at the power of shot fired at high velocities to penetrate iron armour, and the capabilities of the iron armour for resisting solid shot. Not much is known positively respecting this, but the following facts are tolerably well ascertained: that the 110lbs. Armstrong shot has a velocity of 1200ft. per second, the 68lbs. shot a velocity of 1580ft. per second, and the 156lbs. a velocity of 1700 feet per second; and that these shots have respective penetrating powers of 158, 170, and 430. It is also believed that, while the penetrating power of shot is as the square of its velocity, the resisting power of a plate is as the square of its thickness. This has not been absolutely proved by experiment, but is probably not far from the truth, and any error is due to the difficulty of manufacturing thick plates as homogeneous as thin ones. Assuming then the two following data, that the 68lbs. shot just does not pierce a 4in. plate, and that the 156lbs. shot just does not pierce a 4½in. plate, backed by 3in. of iron, it can be determined approximately what thickness of plate and backing would be required to stop a given shot having a given velocity, and what size of vessel would be needed to carry such armour and also to possess all the qualities necessary in a ship of war. At present the shot fired from the most powerful gun yet made is stopped by a 4½in. armour plate and 3in. backing of iron, and the vessel necessary to carry such armour is of 7200 tons burden, and has a displacement of 10,500 tons, a saving in weight of 600 tons being here made by the adoption of the iron backing.

TABLE OF DIMENSIONS OF VESSELS TO CARRY DIFFERENT THICKNESSES OF ARMOUR.

	4½-inch armour.	7-inch armour.	11-inch armour.
Length of vessel	400 feet	500 feet	600 feet
Breadth	60 feet	70 feet	80 feet
Tonnage	7200 tons	12000 tons	20000 tons
Horse-power of engines	1800 h.p.	2000 h.p.	3000 h.p.
Weight of engines	1800 tons	2600 tons	3000 tons
„ armour	2000 „	4300 „	10000 „
„ hull	2000 „	3700 „	5000 „
„ coals	4000 „	5000 „	7500 „
„ armament	700 „	1000 „	1500 „
Total displacement	10500 tons	16000 tons	27000 tons
Weight saved by adoption of iron backing	600 tons	1500 tons	4000 tons

Although however no shot has penetrated the strongest armour hitherto made, guns will doubtless be made to pierce it, for an Armstrong gun is now being manufactured to throw a 300lbs. spherical shot, and guns will probably be made to throw 400 and 500lbs. shots. On the other hand, although 4in. armour is no longer invulnerable, it must not be considered that the thickness of armour cannot be increased because a vessel could not carry the additional weight; and the writer wishes to show that when the more powerful guns are manufactured and used in large numbers not only can the shot be stopped by armour of reasonable dimensions, but this armour can be carried by vessels of such moderate dimensions as to offer a fair prospect of the race between armour and artillery being continued for the next twenty or thirty years. Thus taking the gun now in progress for throwing a 300lbs. spherical shot, which may be assumed to have a velocity of 2000ft. per second at a range of 200 yards, this shot may according to the preceding data, be stopped by a plate 7in. thick and backed by 4½in. of iron, as shown in (Fig. 11). The minimum vessel required to carry such armour from end to end would be of 12,000 tons burden and would be propelled by engines of 2000 horse power at a speed of 15 knots per hour; 1500 tons weight would be saved in the construction by the use of iron instead of wooden backing. Assuming still further that a gun is made to throw a spherical shot weighing 500lbs. having a velocity of 2500 feet per second, such a shot could on the same data be stopped by 11in. armour plates backed by 8 inches of iron, as shown in (Fig. 12), and this armour could be carried from end to end by a vessel of 20,000 tons burden and 3000-horse power, which would be under the size already attained in the Great Eastern. A comparative calculation of these vessels is given in the accompanying table.

It must be borne in mind that these vessels are coated from end to end; and smaller vessels can be made, but they must be only partially coated with these heavy plates. It will thus be seen that the days of armour-plated ships do not end with 4½in. armour, but that there will always be a race between armour and artillery: defence has up to the present time had rather the best of it, but that will not last long. It is only to be hoped that it may long remain a friendly race between artillerists and constructors of armour.

INSTITUTION OF CIVIL ENGINEERS.

ON AMERICAN IRON BRIDGES.

BY MR. ZERAH COLBURN, C.E.

The great number of timber bridges in America might be accounted for from the fact, that the first cost of the truss or superstructure of a timber bridge of any given span, was generally less than one-half that of an iron bridge of the same strength. Iron had been occasionally employed since 1885, but only within the last ten or twelve years to any extent.

Cast-iron tubular arches, including one of 80ft. span, were erected from the design of Major Delafield, about the time when similar arches were adopted by the late M. Polonceau, in the construction of the Pont du Carousel, over the Seine. Major Delafield's arched ribs were elliptical in section, the transverse vertical axis being about four times the length of the conjugate axis. In 1858, an aqueduct bridge was erected at Washington, by Captain Meigs, in which the two arched ribs were formed of water pipes, through which the water flowed. The span of this bridge was 200ft., the rise being 20ft. The pipes were circular in section, 4ft. in diameter inside, and 1½in. thick. This bridge was 28ft. wide over all, and the roadway was of timber, supported on wrought-iron spandrils. The bridge was tested with the arched ribs filled with water, and with a load of 125lbs. per square foot upon the roadway, making the total weight on each rib about 350 tons. The thrust of one-half of this weight upon each abutment would be about 470 tons, corresponding to a strain of 2 tons per square inch of sectional area of iron in the pipes. This strain did not include the pressure of the water in the pipes, which were proved to 300lbs. per square inch. These examples were, so far as the Author was aware, the only iron arches yet completed in the United States: and with the exception of a few pivot bridges, and one or two ornamental bridges in the Central Park at New York, they comprised nearly all the cast-iron bridges in that country.

There were a small number of plate, or boiler iron bridges. The first was erected in 1847, in place of a timber bridge, by Mr. Millholland, on the Baltimore and Susquehanna (now the Northern Central) Railroad. This was 50ft. span, and the two girders were each 6ft. deep, the two sides of each being formed of plates ½in. thick. Between the sides at the top a timber 12in. square was bolted as a compression member, and the top was further strengthened by two wrought-iron bars, 5in. deep by ½in. thick, while four similar bars were rivetted along the bottom of each girder. The sides were stiffened by stay-bolts, enclosed in cast-iron distance pieces, 12 inches apart from centre to centre. The centre of each girder was placed exactly under the rails, which were spiked to the timber forming the compression member. The breaking strain of the pair of girders was equal to 259 tons of distributed load, and the weight of the bridge was 14 tons. When completed, this bridge was coupled at each end to a railway waggon, and was slung by chains to a temporary timber truss. It was then taken 19 miles by railway, run exactly over the place it was intended to occupy, the existing timber bridge was cut away, and the girder bridge lowered with the permanent way ready for traffic; the whole operation not having caused an interruption of more than two hours.

Having been long accustomed to trussed timber bridges, American engineers, in adopting iron, naturally employed it in trusses also. But, before describing the various forms of iron truss bridges, the strength of American iron was referred to. It appeared from a vast number of experiments made by the United States Ordnance Board, that there was but little iron in any American cast guns of a less tensile strength than 11 tons per square inch; and in 1851, the Author had himself seen portions cut from 11in. guns, weighing 6 tons 15 cwt., tested up to 16·14 tons. The transverse breaking strength of a large number of samples of re-melted iron, when reduced to the English standard of a bar 2in. deep and 1in. wide, resting on supports 3ft. apart, varied from 27¾ cwt. to 48·1 cwt., the general strength being 34 cwt. The minimum crushing strength of the irons experimented upon was 37¾ tons and the maximum 77¼ tons. Experiments made by the Franklin Institute twenty-five years ago, showed the mean tensile strength of cast-iron at the first melting to be 9½ tons; and the iron now employed by engineers in Philadelphia bore from 7·14 tons to 10·2 tons. In 1858, Mr. Albert Fink tested the iron used in the construction of a large bridge on the Louisville and Nashville Railroads. When the results were reduced to bars 2in. deep by 1in. wide, on supports 3ft. apart, the minimum breaking weight was 29½ cwt. mean 32·68 cwt., maximum 39 cwt. This iron was a mixture of two-fifths cold blast, two-fifths hot blast, and one-fifth scrap. With regard to wrought iron, experiments made by the United States Board of Ordnance gave a tensile strength varying from 17 tons to 33·3 tons per square inch; and those of the Franklin Institute, a mean strength of 26 tons for plate iron. At the present time 27 tons was generally expected of American boiler plate. Other ex-

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periments were also quoted to the same effect; and it is remarked that, from what had been stated, American engineers might work up to rather higher strains than were commonly allowed in this country. The high qualities of the best American iron were due to the purity of the ore and of the fuel employed in the manufacture. In bridges of less than 150ft. span, even when loaded with a weight of 1·36 ton per lineal foot of single line, the strains did not exceed 3·57 tons per square inch on wrought iron in tension, and 4·46 tons per square inch on cast-iron in compression.

Of the iron truss bridges that were described, all had certain peculiarities in common, distinguishing them from the trussed structures adopted in this country. In almost every case the compression members of American iron trussed bridges were of cast-iron cylindrical or octagonal pipes. These simply abutted, end to end, against each other; and although means were employed to prevent lateral motion of the ends, flanges and bolts were never introduced for that purpose. Another, and one of the most important peculiarities was the depth of truss, a depth exceeding that employed by English engineers, except in rare instances, as at Chepstow and at Londonderry. American engineers considered a depth of one-eighth for spans of 200ft. as only moderate; for shorter spans depths of one-seventh and one-sixth were common; and in the case of one bridge of 120ft. clear span, the depth was 23ft., or nearly one-fifth of the span. It should, however, be observed that, in some of the American trusses, the arrangement of the tension members was such that, if the depth of the truss were not considerable, the diagonals would be inclined at hardly more than 8° or 10° from the horizontal; in which case a very large quantity of material would be employed, in proportion to the supporting power obtained. No American iron or timber bridges were ballasted; nor had they any floor, only a foot-path of planks. In bridges having the rails at, or above the level of the top chords, known in the States as "deck bridges," parapets were seldom employed; and the trusses were often so short a distance apart, that a passenger, on looking out of a carriage window, was unable to discover any support beneath the train. In no bridges of two or more spans were the trusses made continuous over a pier; each span being always treated as a bridge by itself.

One of the earliest iron trusses adopted in the States was a trellis, known as Rider's Bridge. Cast-iron T, or angle-irons, were employed in compression, and wrought-iron bars in tension. These bridges were so slightly proportioned that they occasionally broke down, and the Author was not aware that the plan was now adopted in new structures.

A detailed description was then given of a Murphy-Whipple bridge, having a span of 125ft., with the railway supported on the lower chords. It was for a double-line, and there were three trusses, 14ft. apart, from centre to centre, the strength of the middle one being about one-half greater than that of either of the others. The trusses were 23ft. deep, or 0·184 of the span. The top chord was formed of cylindrical cast-iron pipes, and the bottom chord of a chain of square bars, 10ft. 5in. in length between the centres of the eyes. Upright cast-iron posts, placed at the same distances apart, divided the truss into panels, and as the posts were in two lengths, they were each trussed by four round rods, to prevent lateral failure. The diagonals were in pairs of square rods, and were formed also as eye-bars, grasping pins 2¼in. diameter in the top chord, where the pipes abutted upon each other, and pins 3¼in. diameter in the bottom chord, thus connecting the links, or bars, of which it was composed. The diagonal tension bars only crossed each other in two panels on each side of the centre of the truss. The top and bottom chords were braced horizontally, with transverse and diagonal bars. The railway bars were supported upon longitudinal timbers, which rested upon transverse wrought-iron rolled beams. The total weight of the superstructure complete was 102½ tons, or 8 cwt. per foot of single line. With an additional distributed load of 3000lbs. per lineal foot on each line, the tensile strain at the middle tension rods would be 4·27 tons per square inch in the middle truss, and 3·12 tons per square inch in the outer truss; but, with a train on a single line only, the ordinary working strains did not exceed 2¼ tons per square inch in tension, nor three tons in compression.

In 1861, an iron bridge was erected on the line of the Pennsylvania Central Railroad, across the Schuylkill at Philadelphia. It had two clear spans of 192ft. each, and one pivot span, or turning bridge 122ft. long. The construction was similar to that just described, but the truss was only 19ft. deep. The upright posts or struts, were of wrought-iron, so rolled that when two bars were put together they formed on octagonal tube. The top and bottom chords of the turning bridge were of wrought-iron rolled beams, so that either might resist extension or compression. The three spans for a single line contained an average of 5 cwt. of wrought-iron, and 7½ cwt. of cast-iron per lineal foot. The nett cost of the bridge, exclusive of masonry, was £8144 10*s*., or £14 4*s*. per lineal foot; the wrought-iron costing £22 15*s*. 6*d*., and the cast-iron £6 11*s*. 3*d*. per ton.

The pivot was of a kind extensively employed for turn-tables. It consisted of a fixed and of a movable cast-iron disc, both grooved to receive a number of steel rollers, each turned to the frustra of a double cone. A circular railway was laid around the pivot, but the wheels only bore upon it, when the bridge was not truly balanced on the rollers. With a load of 14 tons balanced upon one of these bearings, the whole was revolved by a weight of 3½lbs. hung over a pulley, and connected by a cord to the periphery of the turn-table.

The form of truss introduced by Mr. Wendel Bollman was next noticed. In it the load upon each panel was transferred directly to the ends of the truss, through a pair of straight suspension bars, doing duty only in that panel. With the exception of one pair of suspension bars, supporting the centre of the bridge, the bars in each pair were of unequal length, and their lower ends were attached to the upper extremity of a compensating link, in order to allow for contraction and expansion. This bridge could not alter its form under unequal loading. A bridge upon this plan at Harper's Ferry, on the Baltimore and Ohio Railroad, had four parallel trusses for a double line, and a clear span of 124ft. The span was divided into eight panels, and the depth of the truss was 17ft. 6in. The top chords were each formed of a single line of octagonal cast-iron pipes, and the vertical posts were also of cast iron. The strains upon the various parts of the truss caused by the weight of the bridge, and of a load of 1½ ton per lineal foot, were 2·1 tons per square inch in compression in the top chord, and varied from 4·36 tons per square inch in tension in the longer suspension bars to 7·14 tons in the shorter bars. Mr. Bollman had stated, that this bridge was tested with a moving weight of 122 tons of locomotives on one span of a single line, or nearly 1 ton per lineal foot, and that the deflection at a speed of eight miles an hour was 1⅛ inch at the centre.

The iron bridge designed by Mr. Albert Fink had been more extensively adopted than any other on the railways of the United States. In this bridge a pair of diagonal tension bars connected the foot of the principal strut or king-post in each truss, with the ends of the top chord. This pair of diagonal bars supported one-half of the whole weight of the truss and its load. Each half span was subdivided by a strut, and two diagonal tension bars extended, one to the nearest end of the top chord, and the other to the top of the centre post. Each quarter span was again subdivided into eighths, and these again, for spans greater than 100ft., into sixteenths. Under the direction of Mr. B. H. Latrobe, then engineer of the Baltimore and Ohio Railroad, in 1852 Mr. Fink erected an iron bridge of three spans, each of 205ft., where that line crossed the Monongahela river. The depth of the truss was about one-ninth of the span, and the railway was carried at a little above the level of the bottom of the truss. The weight of the bridge including the permanent way, was only ¼ a ton per foot of single line, and with an additional load of 1 ton per lineal foot, the tensile strains upon the wrought-iron did not exceed 5·15 tons per square inch, and the compression on the cast-iron 4·25 tons. The Green River and the Barren River Bridges were then alluded to as being identical in construction to that last described.

The Bollman and Fink trusses for a single line, and in spans of from 160ft. to 200ft., cost £14 per lineal foot, or nearly £28 per ton; while timber bridges of the same span only cost from £5 to £7 per foot. Still, iron bridges now met with an amount of favour, which appeared certain to insure their ultimate substitution for timber bridges. A gradual preference was being shown to the plate girder, as the great annual range of temperature, from 20° below zero to a reflected heat of 130° in the summer sun, was not favourable to the use of cast-iron in structures of such importance as railway bridges.

ACCOUNT OF THE COFFERDAM, THE SYPHONS, AND OTHER WORKS, CONSTRUCTED IN CONSEQUENCE OF THE FAILURE OF THE ST. GERMAIN'S SLUICE OF THE MIDDLE LEVEL DRAINAGE.

By Mr. Hawkshaw (President Inst. C.E.)

The St. Germain's Sluice was situated at the confluence of the Middle Level main outfall drain with the River Ouse, near the upper end of the Eau Brink Cut. This drain was made in 1847, from the designs, and under the direction of Messrs. Walker, Burges, and Cooper. It was deepened by them in 1857, and then had, at the lower end, a bottom width of 48ft., the side slopes being 2 to 1. The level of the bottom was 7ft. under low-water spring-tides in the river, and the rise of the tide at that point was about 19ft. at spriug-tides, the cill of the sluice being 6ft. below low-water spring-tides. The bed of the drain was of soft blue clay, and the sides consisted of variable thicknesses of soft blue clay, peat, yellow clay, and surface soil.

On the 4th May, 1862, the St. Germain's Sluice gave way, thereby admitting the tidal waters, which ebbed and flowed throughout a distance of upwards of 20 miles. A few days afterwards, the western bank of the Middle Level drain burst, about 4 miles from the Sluice, by which 6000 acres of land were inundated. Immediately after the failure of the sluice, the Author received instructions to execute whatever works might be necessary to shut out the tidal waters, regardless of expense. The services of Mr. J. T. Leather were secured as Contractor, who was ably aided by his assistant Mr. E. P. Smith. Mr. Alexander G. Linn was appointed resident engineer. Subsequently, after the cofferdam was closed, finding it impossible to devote so much time to the works as he had previously done, at the Author's request, the Middle Level Commissioners associated with him Mr. T. E. Harrison, who had since continued to act.

Before the author assumed the direction of the works, and directly after the failure of the sluice, an earth and cradle dam was attempted to be thrown across the drain, at about 500 yards from the fallen sluice. This was relinquished shortly after the permanent cofferdam, of pile-work, was commenced; which the Author considered was the only plan likely to be effectual, and the site finally fixed upon for which was about 880 yards from the sluice. The cofferdam might be thus described:—Temporary piles were first screwed into the ground, upon which a staging was erected for the pile-driving engine. Two rows of sheet-piling, 25ft. apart, were then driven transversely down the slopes of the drain on each side, from the centres of the banks to within 20ft. of the bottom, leaving a central space of 88ft. of cofferdam to be afterwards completed. In this portion of the dam the piles were placed in pairs on each side, 7ft. 6in. apart from centre to centre, and with a space of 7in. between each pair. The grooves thus left were for the reception of sliding panels, to be used to fill up the intervals between the several twin piles. Waling pieces of whole timbers were fixed to the inside and the outside, both at the top and as near the level of low water as possible. As the piles were driven, struts and ties were inserted, and strongly-framed raking struts were secured against the dam and against abutments of piles, backed with concrete, on the land. The panels were composed of timbers 7in. thick, and of variable lengths, firmly bolted together, and further connected and weighted on one side by flat wrought-iron plates. In order to put these panels in place, a frame was erected, from which they were suspended, and from which they could be lowered, and raised, if necessary, by pulleys.

The rush of water through the dam was materially increased, while the piles for the panels and the walings were in place; so that, at times, the difference

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of level between the water on the two sides of the dam was considerable. Aprons, extending the whole width of the drain, and for some distance up the slopes, were formed on both sides of the dam, of sacks of clay, and of gravel, puddle, and stone. Only sufficient stone was deposited in the centre of the dam to stiffen the clay; but large quantities of puddle were repeated thrown in at slack water, most of which was washed away by the rush of water, which acquired a velocity of 8 miles an hour.

The first, or lower tier of panels was 7ft. deep, and pointed at the lower end, so as to be driven into the mud. Inasmuch as they could not be driven to the same depth, the second set was so arranged as to raise the panelling to the uniform hight of low-water spring-tides. During these operations, sacks of clay and gravel were deposited on the inside and the outside of the dam; but, although the aprons were extended, only a few sacks of gravel remained in the inside. It now became clear, that the water could only be excluded, by shutting the dam at one operation. To accomplish this, the necessary panelling, which had to be 12ft. deep, was suspended from the scaffolding, so as to be dropped into place at slack-water neap-tides, when the differential head for the dam to sustain was the least. On the first attempt to close the dam, three of the twin piles on the lower side gave way, releasing some of the bottom panels, after the tide had receeded 3in., and when there was a head of 8ft. The other panels were readily lifted and removed; and sheet-piling was then driven up to the level of the lower waling pieces, thereby filling in the spaces between the broken piles. The second attempt, which proved completely successful, was postponed until the succeeding neap-tides, when the panels were dropped into their places in twenty minutes, at low-water of ebb tide, that time being more convenient, the difference of the head at high and low water not being considered of sufficient importance to counterbalance other advantages. After the panels were lowered, the inside of the dam was immediately filled with clay; sacks of gravel and clunch being deposited in the centre. So complete were the arrangements, that the raising of the dam was kept in advance of the rise of the tide, and before high water, the operation was completed, the dam not exhibiting the slightest indication of failure, or of weakness. The cofferdam was commenced on the 16th of May, and the tidal waters were shut out on the 19th of June, 1862.

During this time, the means to be adopted for the future drainage of the Middle Level received serious attention. After careful consideration, the author determined that, in addition to such drainage as could be obtained through Salter's Lode Sluice, the old outlet into the Ouse, syphon pipes should be laid over the cofferdam. This plan of discharging water was not to him novel, having pursued it in 1839, when engaged on the Manchester, Bury, and Bolton Canal. The syphons were sixteen in number, and were laid transversely across the dam, at an inclination of 2 to 1 at the sides, and horizontally over the top. Each end was terminated by a horizontal length, containing the upper and lower valves, laid 18in. under low-water of spring tides, the top of the syphons being 20ft. above the same level. The total length of each syphon was 150ft. The syphons were of cast-iron, 3ft. 6in. internal diameter, and the thickness of the metal was (excepting at the socket ends, where it was thicker,) 1¼in. They rested on the top of the dam, and on inclined framework, supported on piles, at the sides. Underneath the extreme ends of the syphons, sheet-piling was driven across the drain. Above the sheet-piling, the spaces between the inclined framework, to the underside of the syphons, were filled in with clunch, clay, and gravel, so as to form a solid and impervious embankment. The bottom of the dam, at the inlet and outlet of the syphons, was protected by substantial wooden aprons, extending across the drain; and a row of piles was driven on each side, inclining towards each other, and contracting the channel to a width of 60ft., so as to keep the "wash" off the slopes of the drain. The upper or inlet, valve consisted simply of a loose hanging flap of teak wood, working inwards as soon as the outward was the preponderating pressure. The lower, or outlet, valve was of cast-iron, turning on a hinge at the top, and fitted with a balance weight, which was capable of resisting an interior pressure, but could be readily released when the valve was converted into a flap opening outwards. The reason for adopting two valves was for the purpose of enabling the syphons to be put into operation, either by exhausting the air, or by filling them with water; but at present only the former method had been tried.

The syphons were put into action by exhausting the air from the inside, by an air-pump having three cylinders, each 15in. diameter with a length of stroke of 18in., worked by a 10 H.P., high pressure, steam engine. Each syphon could be shut off, or be brought into operation at pleasure, by means of slidecocks, fixed on vertical pipes, communicating with a transverse horizontal pipe, in connection with the air-pump. An overflow pipe showed when the syphons were full of water; and glass gauges were also attached to some of the syphons for the same purpose. The pipes were cast by Messrs. Cochrane and Co., and the steam engine and air-pump were manufactured by Messrs. Easton, Amos, and Sons.

After the breach occurred, it became evident that all attempts to stop it should be abandoned. The area flooded was surrounded by banks, which confined the mischief within certain limits. As soon as the cofferdam was completed, and the tidal waters were excluded, the breach was closed, by first tipping stone to form a footing for an embankment of clay to the level of the bottom of the drain, above which a small quantity of clunch was mixed with the clay, to stiffen and weight it. The total quantity of material used to restore the bank was about 2500 cubic yards. The bottom of the drain, where the scour had taken place, was also repaired, and the banks generally were put in good order. After the breach was secured, the water on the inundated land was let off, through the Marshland Smeeth and Fen drain and the adjoining Marshland sewer.

In conclusion, the author remarked, that he believed the syphons would be found to answer all the purposes of a permanent sluice. They possessed, moreover, the advantage of not rendering the safety of a district dependent upon single pairs of gates; for it was clear, that any one or more of the syphons might be damaged or destroyed, without affecting the operation of the others, or endangering the district.

In an Appendix, tables were given, showing the quantities of the several materials used in the construction of the dam and the syphons, as well as the results of the working of the syphons.

ON THE COMMUNICATION BETWEEN LONDON AND DUBLIN.

By Mr. Watson, M.A., Assoc. Inst. C.E.

Holyhead, the nearest point of land in Great Britain to the metropolis of Ireland, was naturally thought of at an early date as a convenient port of departure and arrival for the mails. This route had accordingly been used for a century and a half, and was recognised in an Act of Parliament passed in 1729; but the communication between London and Dublin was then irregular, and the time occupied on the journey protracted. Travelling through North Wales was attended with difficulty and fatigue, and the passage of the Channel was contingent on the state of the weather. Though measures of improvement were proposed before the close of the last century, no effectual steps were adopted, until after the legislative union had taken place between Great Britain and Ireland, in the year 1801. The public commissions were constantly engaged in inquiries, and committees of the House of Commons presented no less than twenty-five reports on the subject within ten years. These investigations had reference, principally to the land part of the journey; and by means of large grants of public money, amounting, it is believed, to nearly one million sterling, in 1826 a continuous and easy road was completed between London and Holyhead, so that the entire distance of 267 miles could be performed, with regularity, safety, and comparative comfort, in thirty-four hours. Improvements for the sea-part of the journey also engaged some degree of attention; but while sailing vessels were in use, it was not thought that much could be gained in the passage of the Channel. In 1819, a steam-vessel was placed on the Holyhead station for the summer and autumn, and soon afterwards the *Royal Sovereign* and the *Meteor* were especially built for the Post Office service, with engines by Messrs. Boulton and Watt, and then the sailing cutters disappeared. The average length of the passages of these two steam vessels, in the first year, between Holyhead and Howth, was seven hours and thirty-three minutes; the shortest passage was made in five hours and forty-eight minutes, and the longest was stated to have occupied upwards of twenty-three hours.

The mail communication between London and Dublin had been thus long maintained exclusively by way of Holyhead; but the rapidly-growing importance of Liverpool led to the establishment, in 1826, of a direct postal service between that port and Ireland. Steam vessels had been placed on that station, by private enterprise, as early as 1819, for the conveyance of passengers during the summer months; and in 1823, Mr. C. Wye Williams (Assoc. Inst. C.E.) originated a company for the maintenance of a regular steam communication throughout the entire year, for the conveyance of passengers and of merchandise. As the railway from London to Liverpool was opened in 1838, that line became for some years the most expeditious route to Dublin, and the mails and passengers nearly deserted Holyhead. Liverpool did not long, however, retain this superiority; for, in 1849, a continuous line of railway was completed between London and Holyhead, by private capital, twenty-three years after the continuous line of road had been constructed, by direction of the state, and principally by grants of public money. The conveyance of the Irish mails was then transferred from Liverpool to Holyhead, and the large and powerful packets of the Government and of the Company, which had carried the night mail under contract for the previous ten years on the Liverpool line, were appropriated to other duties.

During the time these changes were in progress, the packet service was transferred from Howth to the Asylum Harbour at Kingstown, which was ultimately connected with Dublin by a railway six miles in length. The only link then remaining to complete the communication with Ireland was a superior class of vessels. The Government having decided on building four vessels each of 700 tons burthen, with engines of 320 horse-power, the best result was admitted to have been attained; as the rate of speed of the *Banshee* at the measured mile was upwards of 18 statute miles an hour, or nearly four miles in excess of any previously obtained. After a short trial of this service at heavy cost, the Lords of the Admiralty determined that it should be performed by contract, as had previously been the case on the Liverpool line, and that the average speed should be 12 knots, or nearly 14 statute miles per hours. This service lasted from May, 1850, until October, 1860, and was performed within the stipulated time.

Further improvements being still demanded, a plan was submitted to Government, and a new postal contract was entered into, the main provisions of which were, first, that the entire distance between London and Kingstown, instead of to Dublin, was to be performed in eleven hours, allowing four hours for the sea passage; secondly, that four steam packets should be specially built for the service; thirdly, that express trains should be appropriated exclusively to the Irish traffic; and fourthly, a morning and evening departure from each capital. The vessels referred to were each 2000 tons burthen, and in their dimensions and general arrangements were nearly identical. Three, the *Connaught*, the *Ulster*, and the *Munster* were built by Messrs. Laird, and the one, the *Leinster*, by Mr. Samuda. The ships were of iron, timber having been used only for the decks and cabin fittings. The length of the *Connaught* between the perpendiculars was 334ft., the beam was 35ft., and the depth 21ft. There were nine principal water-tight bulkheads, which not only provided for the safety of the ship in case of accident, but added greatly to the strength. The bulwarks were of iron plates, in continuation of the sides of the vessels, without any break for gangways. Between the paddle-boxes there was an upper deck, which further added to the strength amidships; and on this was placed the wheel and binnacle. The entire of the main-deck, from the foremost funnel forward, was covered by a hurricane-deck, which had been found of great advantage in throwing off seas in heavy weather. The engine in all the vesels were on the oscillating principle. Those for the *Connaught* and the *Leinster* were made by Messrs. Ravenhill,

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Salkeld and Co. The cylinders were 98in. in diameter, and 6ft. 6in. stroke, the air pumps being 54in. in diameter, with a length of stroke of 2ft. 6in.; the boilers were multitubular, eight in number, four at the end of the engine-room space, arranged in pairs, with one funnel to each pair; there were five fire grates in each boiler, and the total grate surface was 677ft. square, the heating surface exceeding 19,000ft.; the wheels were 31ft. in diameter to the outside of the floats, which were feathering, fourteen in number, and each was 12ft. long by 4ft. 4in. broad. On the trial trips, the engines worked at the rate of 25½ revolutions per minute, with 25lbs. of steam. The mean of the runs of the *Leinster* at the measured mile was 20½, and of the *Connaught* 20¾ statute miles per hour. The engines of the *Ulster* and the *Munster* were constructed by Messrs. James Watt and Co.; the cylinders were 96in. in diameter, with a length of stroke of 7ft.; the wheels were 33ft. in diameter; the boilers had each six fireplaces, giving an equal extent of grate surface with the other; the heating surface measured 18,033 square feet; these engines were erected on board the vessels in the Liverpool Docks, and from a return of observations made on several trips, there being no measured mile at that port for testing speed, the rate attained appeared to have been 20½ statute miles per hour. One of the principal peculiarities, which made these vessels of so unique a class, was the post-office fitted for sorting letters on the passage, so that the letters were ready for delivery, or to be forwarded to their destination, on the arrival of the vessels, either at Kingstown or at Holyhead. About two hours were thus saved in the transmission of the mail.

The contract with the Postmaster-General had appointed January, 1861, for the commencement of the improved service. But as the vessels were in readiness some months sooner, it was commenced in October, 1860, and had since been continued without interruption. From what had been already stated, it would have been seen, that the difference of speed between the four vessels on the trial trips was inappreciable—a matter of paramount importance to a mail service. Thus, while the shortest passage of the *Connaught* across the Channel occupied three hours and fourteen minutes, being at the rate of about twenty miles an hour; the shortest passage of the *Leinster*, the *Ulster*, and the *Munster* were three hours and twenty minutes, three hours and eighteen minutes, and three hours and twenty-two minutes respectively; their average performance for the two years and five months during which they had been on service, inclusive of the trips made in fogs, gales, &c., was still closer, as follows:—

			Hrs.	Min.	
The *Connaught* made	1064	passages in	3	51½	on the average
„ *Leinster* „	919	„	3	52¼	„
„ *Ulster* „	925	„	3	55	„
„ *Munster* „	920	„	3	58 1-10ths	„

The consumption of coal in the first few months was considerably in excess of the quantity originally estimated. Steam of from 25lbs. to 28lbs. pressure was then used; but satisfactory arragements had since been made to reduce the consumption, while the additional time occupied on the passage was but a few minutes, and was still within the time allotted to the sea service; the engines in the *Ulster* and the *Munster* had been provided with superheaters, but experience had not shown any advantage, either as reducing the consumption of coal, or as tending to a superior performance. These vessels had made in the aggregate 1845 passages, in the average time of 3 hours 56½ minutes, and had consumed 30 tons 7 cwt. of coal as the average of each, inclusive of the quantity required for raising steam, which was considerable. The *Leinster* and the *Connaught*, without superheaters, had made 1838 passages in the average time of 3 hours 54 minutes, and had consumed, inclusive of raising steam, on the average, 30 tons 1 cwt. of coal.

It was satisfactory to be able to state that the ships had, so far, needed no repairs, being now in as perfect a condition as when the service was commenced, in 1860. The frequency of docking, for the purpose of cleaning and coating, had afforded constant opportunities of examination, when painting only had been required.

In conclusion, the author referred to the admirable performance of the land portion of the journey, from London to Holyhead, by the London and North-Western Railway Company; the punctuality in the arrival of the trains on the jetty at the latter place, the speed maintained, and the excellence of the carriages, were the subject of universal approval. Further improvements, at present not thought of, might yet be brought into operation; but there appeared to be no reason for apprehending that the communication by way of Holyhead would ever cease to be the best for postal purposes, and to be preferred by the travelling public, so long as the entire distance between London and Dublin could be accomplished within eleven hours and a half.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

NOTE AS TO TWO EVENTS IN THE HISTORY OF STEAM NAVIGATION.

By W. J. Macquorn Rankine, C.E., LL.D. F.R.S.

(1.) An interesting paper was lately read to this Society by Mr. Dyer, containing a history of a series of important events in the progress of steam navigation.

(2.) It is to be regretted, however, that the author has noted either very slightly or not all, what appears to have been an event of paramount importance in the first adaptation of the double-acting cranked steam engine to drive a paddle-wheel. Before that adaptation was made, the success of all attempts at steam navigation, such as those of Jouffray, Rumsey, Fitch, Miller, and Taylor, &c., had been only temporary, because of the rudeness of the machinery for communicating motion from the piston to the shaft.

(3) That first adaptation was unquestionably accomplished by William Symington in 1801, as is proved by authentic documents which have been published by Mr. Woodcroft in his *Origin and Progress of Steam Navigation*. Symington, instructed by the failure of the ratchet-work engine which he had made for Miller's boat, fitted up the *Charlotte Dundas* in 1801, with a double-acting horizontal cranked engine, and this made her what Mr. Woodcroft justly called "the first practical steamboat." Her speed, when running alone, and not towing other boats, was six miles an hour.

(4.) The use of this vessel was abandoned, not from any fault in her construction or working, but because the Directors of the Forth and Clyde Canal feared that she would damage its banks. Yet the man in all Britain who possessed, at that time, the greatest practical experience of the working of canals—the Duke of Bridgewater—was not deterred by any such apprehensions from ordering, in 1802, *eight* similar vessels, from Symington, to be used on his canal.

(5.) The death of the Duke of Bridgewater, early in the following year, prevented the execution of that order. But Symington had evidently done all that lay in his power, and all that was necessary, to convert the steamboat from an awkward piece of experimental apparatus to a practically useful machine; and the honour paid to his memory ought not be lessened because the career of his invention was cut short by a misfortune.

(6.) There is nothing in this to detract from the honour which is justly paid to Fulton, as having been the first to practice steam navigation on a great scale, as a commercially profitable art.

(7.) Another event passed over in the paper to which I have referred, is the first introduction of commercial steam navigation into Europe, which was effected on the river Clyde, in 1812, by Henry Bell, as is proved by documents cited in Mr. Woodcroft's work, already referred to.

ON THE INTRODUCTION OF STEAM NAVIGATION.

By Mr. Dyer.

In Dr. Rankine's paper, entitled "Note on two Events in the History of Steam Navigation," he calls attention to my paper, "On the Introduction of Steam Navigation," and expresses regret that "the author has noted either very slightly or not at all, an event of paramount importance:—the first adaptation of the double-acting cranked steam engine, to drive a paddle-wheel." Now, I own to have taken no notice at all of this double-crankod motion, simply because I did not consider it of much importance in attaining success in steam navigation. I had before me Mr. Woodcroft's interesting treatise, and I fully appreciated his advocacy of the claims of Mr. Symington for having fitted up the *Charlotte Dundas*, as the first practical steam boat, in 1801. This fact is fairly stated in my paper.

I aimed to place before the Society the several inventions and discoveries relating to the use of steam power to supersede that of wind to navigate vessels, and to prove that the final success was due to the invention of Watt's steam engine. No great stress need be laid on the double-cranked action, or on any of the other methods used for transmitting the power to the paddle wheels. The principles involved in overcoming the resisting forces by steam power in navigation, are entirely apart from those relating to the mechanical means of converting rectilinear into circular motion. It seems strange that such able engineers as Dr. Rankine and Mr. Woodcroft should have given this prominence to the said double-crank action. Whatever may have been the degree of success in the case of the *Charlotte Dundas*, in 1801, and whatever may be said about the bar to further progress of Symington's inventions by the Duke's death, the fact remains clear that his schemes died out with the Duke, as no more was heard of them after the *Charlotte Dundas*, and from some cause, she was discontinued; and it was in fact fifteen years after her advent before the *Margery* came out from the same waters to enter the Thames in 1816. What shall be said of the enlightened of Glasgow, if Symington's practical steamboat was suffered to rot and be forgotten, leaving no successor, and the inventor himself to remain unrewarded and unnotioed for fifteen years.

Through the limited space allowed for the abstract of my paper, Dr. Rankine was misled respecting the other event, also cited by him from Mr. Woodcroft's book, namely:—that I had passed over the first introduction of steam navigation into Europe, by Henry Bell, in 1812; for in my paper due notice is taken of this well known experiment of Mr. Bell. Although his trial boat proved a failure, on account of its being a very small one, and of his want of pecuniary means for continuing or extending the experiment, and the lack of any aid or encouragement afforded him by others, yet his trial boat served as the model for constructing the *Margery*, three years after, which, as I have before said, was a success, and the first steamboat on English waters. I therefore think that due honour should be paid to the name of Henry Bell, for his spirit and enterprise, and a due stigma cast upon the capitalists who allowed him to sink under pecuniary pressure, from which he ought to have been relieved by them in so important an enterprise.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.

NEW MARINE PROPELLER.

At a well-attended meeting of this Society, held on the 2nd ult., Mr. Joseph Newton, of H.M. Mint, President, read a paper on a "New Mode of Marine Propulsion," suggested by Mr. Vaile. The extreme length to which the paper extended renders it impossible for us to do more than summarise the chief features of Mr. Vaile's proposed plan.

Mr. Vaile proposes to apply to ships or boats one or more submerged endless chain propellers, with feathering floats. The latter would be adapted in form, number, and dimensions to each particular vessel to which they might be applied. Such is briefly the character of the invention.

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Mr. Newton stated, it might be objected at the very outset that there was nothing of novelty about Mr. Vaile's scheme. A closer examination and inquiry would demonstrate the reverse to be the fact. Mr. Vaile's propeller possessed features which distinguished it sufficiently from all previous plans of an analogous kind. Those features mainly consisted in the shape of the floats, their mode of attachment to the travelling chains, their perfect and simply effected feathering properties, and the total submergence of the entire apparatus when in action.

Mr. Newton stated, that by enlarging the chain wheels of the Vaile propeller, increased breadth might be given to the floats. Their breadth might, indeed, be always made to equal the diameter of those wheels minus the diameter of their shafts, and a few inches of clearance between the shafts and the upper edges of the acting floats. Thus, for instance, if wheels of 10ft. diameter were used with shafts of 12in., and 6in. of clearance were allowed, the floats would be 8ft. 6in. broad, and as long as the beam of the vessel would permit.

As in a ship expressly constructed for the reception of this kind of propelling apparatus, one propeller would be placed on either side the keel, and nearly as low down, it was contended that the floats travelling with equal velocity, and having a direct thrust aft, must be far more effective than either screw or paddle-wheel.

It had been found in practice impossible to drive a ship at high rates of speed without incurring the penalties of excessive expenditure of power and fuel. This fatal evil was due principally to the inadequate area of propelling surface in proportion to the bulk and weight to be moved. With the screw, the amount of acting surface was limited by the keel and water-line. With the paddle-wheel it was governed by the size of that wheel, which again was restricted to a reasonable diameter. No such limitations existed with the Vaile propellers. These admitted of the employment of a number of floats of equal area, and ensured them always acting simultaneously upon the water. The floats, too, might be of much greater depth and length than those of the ordinary paddle-wheel. A perfect correspondence will, indeed, be established between the power given out by the engines and the media for receiving and dispersing that power—the floats.

This could never, or at least had never been the case with either screw or paddle-wheel. The evils of "slip," so considerable in the action of both its competitors, would be economised by the Vaile propeller. It was well understood that although by the agency of the screw, and by that of the paddle-wheel, a speed of from ten to fifteen knots had been obtained, yet that if a higher rate of speed was attempted, the result was most unsatisfactory. The slip, at all times great, now became enormous. It increased in a much greater ratio than the speed of the vessel.

The lowness of the position of the Vaile propellers gave them, in the matter of slip, a strong claim to superiority. The floats obtained thereby a hold on the densest water, through which the vessel moved, and would thus *at all times* act with their full propelling force. Increased speed must follow the application of increased steam power, and slip could not increase in a greater ratio than the ship's velocity. Constant submergence, constant action, and perfect feathering were the ruling characteristics—the alleged advantages of the chain propeller of Mr. Vaile.

Both screw and paddle wheel, when in a heavy sea were from alternate direction and deep submersion, frequently ineffective, and to use a nautical but expressive phrase they both at such times "ground up" the power of the engine without producing the "push-a-head" effect required. Mr. Newton remarked that there was no grinding up of power with the Vaile propellers, they were calculated to absorb the full power of the engines and to give it out with perfect effect. Mr. Newton then proceeded to say the power of steering and manœuvring a vessel independently of the rudder's action, was gained to a considerable extent by these propellers. By driving one ahead and the other astern, the ship might be turned in her own length as on a centre.

PROPOSED CONNECTION OF THE INDIAN AND RUSSIAN RAILWAY SYSTEM.

This is a project broached by Russia and seriously entertained by English engineers, of connecting the Indian and Russian system of railway communication by the Oxus valley and the Caspian. Taking the map, it will be found that the swiftest and almost direct route between Calcutta and London is from Raneegunge to Buxar, there cross the Ganges, and through Oude and Rohilcund to Umballa, joining the Punjaub Railway to Lahore. Thence a fine road leads to Peshawur, and a tunnel under the Indus at Attock is more than half bored. Leaving India, the Khyber Pass is gone through, past Jellalabad and Cabul, through the Hindoo Koosh, and striking on the Oxus, following it as far as Khiva, whence there will be found the ordinary caravan routes to the Caspian, where a Russian steamer waits. Arrived at Astrakhan we shall find in a few years the St. Petersburg Railway completed by Sarata, on the Volga, to that city, and from Lemberg by Kiev to the same place. The route is two days shorter than by the Euphrates Valley, or eight days in all from Calcutta to London. The only difficulty is between Peshawur and the Caspian, and the only engineering trouble would be the Hindoo Koosh. It will be more easy to make a railway in Centrel Asia than along the Ukran coast, where Alexander's army perished, and where it is difficult to protect a line of telegraph. It is not to be expected that the Euphrates Valley line will go further than Bussorah for many years, any more than the Caspian line further than Astrakhan and Peshawur on either side.

REVIEWS AND NOTICES OF NEW BOOKS.

Steam in the Farmyard: Its adaptation to Agricultural Purposes. London: W. Kent and Co. 1863.

Notwithstanding the obtrusively evident advertising character of this pamphlet crops out in nearly every page, and the business object with which it has, doubtless, been written becomes perfectly recognised, there is is so much that is true and valuable for the purpose of reference, upon a subject on which so very much remains to be written and done—practically and systematically—that we feel justified in calling the attention of our readers to the pamphlet. It is full of interesting figures and details, showing the economy attending the substitution of steam in the farmyard and in the field. The General Steam Cultivation Company, upon the direction of which the names of his Grace the Duke of Sutherland and other eminent and extensive landed proprietors will be found, appears to have been originated to obtain a sufficiently large capital for the purpose of supplying upon lease, or to sell upon agreements for payment by instalments, the more expensive steam machinery proposed to be employed for the cultivation of land and for performing the manufacturing operations connected with the farmyard.

A Record of the Progress of Modern Engineering, &c. Edited by W. HUMBER, Assoc. Inst. C.E., and M. Inst. M.E. London: E. and F. N. Spon, 1863. Parts 3, 4, and 5.

Mr. Humber's *Record* certainly improves in quality and excellence. He has made a very interesting selection of works for illustration in the more recently issued parts.

A Short Explanation of the Analytical and Universal Nautical Code of Signals. By Count D'ESCAYRAC DE LAUTARE. London: J. Camden Holten, Piccadilly, 1863.

The Author proposes a very comprehensive, simple, and ingenious system of signalling at sea, which is deserving of the attention of nautical men.

The Science of Ship-building considered in its relation to the laws of nature, by H. BOWLBY WILLSON, Esq., of Canada. London: J. D. Potter, 31, Poultry, 1863.

The author has strung together, in some ninety-eight or one hundred paragraphs, which are not very well assimilated or connected, much that would be very valuable to naval architects or ship builders, after more care has been bestowed upon the present disjointed and crude mass of matter presented by the author. What Mr. Willson goes in for as a midship section of a sea-going ship, is the square, box-like form; and for long, broad, and shallow ships, *strengthened* by a longitudinal bow and string girder. "By this method the ship's keel will become the basis of strength for the whole structure, both longitudinally and transversely, instead of looking to the outer walls, as is now done, for the main support"—*(p. 45)*. Now, as to how new and how useful the "bow and string" contrivance is, the practical experience of many of our readers will enable them to judge of its usefulness, and one or two of them may have acquired that knowledge at a considerable cost. Otherwise, in many respects Mr. Willson has, upon questions of construction and disposition of materials, and the internal and general arrangements of both cargo, ships, and vessels of war, reproduced, to a great extent, the plans of Mr. R. Roberts, Capt. T. R. Symonds, and others. We are, nevertheless, much obliged to Mr. Bowlby Willson for the aid which his pamphlet must give in helping along the common cause of all who are interested in the progress of naval architecture, &c., by ventilating the subject more fully. Mr. Willson, in his preface, pays a well-deserved compliment to a very promising young naval architect, Mr. Thomas Smith, of Randolph, Elder, and Co.'s shipbuildin yard at Glasgow.

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CORRESPONDENCE.

We cannot hold ourselves responsible for the opinions of our Correspondents.
To the Editor of The Artizan.

HEAT AND FORCE.

In all machines it is observed that a considerable loss of power results from friction, and a corresponding production of heat takes place. This production of heat may be fairly considered as the equivalent of the force lost by the friction of the machine.

By agitating a liquid, its temperature is increased because the movements of the mass are changed into molecular movements, by the friction of the particles on each other, and on the interior surfaces of the containing vessels.

As it is an undisputed fact that work can thus be directly converted into heat, the mechanical theory of heat supposes that, conversely, heat is changed into work. In the steam engine heat is obviously the cause of work, but it is by no means evident that part of the heat is actually changed into work, as the new theory supsoses.

It is argued that heat, or the intense molecular motion of ponderable matter developed by chemical agency in combustion, is the source of work in the steam-engine, and that perpetual motion would be realised if a given quantity of heat can, by its passage through the engine, perform exterior work, and still remain undiminished in amount at the end of the operation.

The force of this reasoning depends on the view which is taken of the constitution of the vaporous and gaseous states of matter. The mechanical theory of heat explains the constitution of vapours and gases, by the simple mechanical laws of matter and motion, without the agency of *repulsion*, as the word is generally understood. The legitimate scope of true philosophical inquiry should certainly be to clear away mystery, where possible, and to remove all unnecessary complication from our ideas of the agency of natural forces in the production of physical phenomena; but, unfortunately, the current theory of thermodynamics, by discarding the old idea of molecular repulsion in elastic fluids has introduced fallacies which seriously impair the practical value of an otherwise beautiful doctrine, elaborated with admirable skill by some of the first intellects of the age.

In former papers treating of this interesting subject, in connection with thermic prime movers, I have endeavoured to show that heat, as molecular motion, though the cause of work in the steam-engine, is not *directly converted* into work, and that all the heat which leaves the boiler in the steam should (theoretically) be found in the condenser, only more diluted, or of lower temperature. Such was the conclusion to which the large experiments of Seguin led twenty-five years ago; and Mr. Hirn, of Colmar, after the most elaborate research on the thermodynamical phenomena of the practical working of large steam-engines, not long since arrived at conclusions differing widely from the new theory. Fortunately for truth, the correctness of his valuable facts remains unimpeached, for it seems that M. Hirn has recently altered his views, and *given an interpretation to the facts of his experiments* more in harmony with the general opinion of scientific men, as more particularly enounced in the papers of Professor Clausius on the subject. M. Hirn's experiments showed that, besides the production of work without loss of heat, the tumultuous dashing of high pressure steam from the cylinder of an engine to the condenser produces an actual increase of thermometric heat; and the apparent absurdity of these conclusions disappears if we allow the obvious fact that high-pressure steam must contain some form of energy distinct from that of mere thermometric heat, as described by the thermodynamical theory, though always co. existent with it.

Sadi Carnot, in 1824, likened the dynamical action of heat in the steam-engine to that of water in a hydraulic wheel, the temperature of the steam representing height of fall in the water. Thus, a given quantity of heat concentrated into a smaller space would correspond to a given quantity of water raised to a certain height; the water in descending would produce work, and the heat expanding into a larger space would also produce work. The agents in both cases would remain the same in quantity, but it is evident that the water in its more elevated position contains an amount of work-producing power which it did not possess when at a lower level, and it must have required this work-producing power at the cost of so much energy expended from some other active source. This energy is obviously the equivalent for the work expended in raising the water. So, also, a given weight of low pressure steam, compressed by some exterior force into a smaller volume, contains more work-producing power than it possessed in the more expanded state; and this increase of work-producing power must have cost an equal quantity of energy transferred from the exterior agent. We cannot trace the occult process of the transfer, but the visible results prove that it has taken place, and we find that the energy thus transferred to the fluid has not increased its quantity of thermometric heat, as experiment proves that one volume of steam at ten atmospheres pressure contains the same (or very nearly the same) amount of thermometric heat as ten volumes of atmospheric pressure steam, that is to say, each will raise the temperature of a given mass of cold water the same number of degrees. Thus there is evidently a difference between thermometric heat and calorific energy in elastic fluids.

If we allow that elastic fluids may possess a property of molecular repulsion distinct from the molecular motion supposed to constitute elastic tension according to the current doctrine, we may conceive of the specific energy of high pressure steam as of the energy of a spring wound up; and common observation shows that when a vapour or gas is compressed, and the molecular springs are thus put into a state of greater tension, part of the latent heat of the fluid becomes sensible, and the temperature rises. And, on the other hand, when an elastic fluid is allowed to expand quietly by gradually enlarging the space it occupied, part of the sensible heat of the fluid becomes latent, and the temperature falls. Now, the chemical energy of fire applied to a common steam-boiler, besides effecting the change of the liquid to vapour, produces on the vapour formed the same result as compression from an external source of power. This will appear plainer by tracing the formation of steam in a boiler under gradually increasing pressure. Each fresh particle of steam formed increases the density of the steam already existing, and changes part of its latent heat into sensible; and if the first portion of the steam formed be supposed to remain in the upper part of the vessel unmixed with that which goes on forming below, it is perceived that its pressure will go on increasing with a corresponding rise of temperature caused by a change of its latent heat into sensible, independently of any direct communication of heat from beneath. The constitution of high pressure steam is obviously the same whether it is generated directly at high pressure in the boiler, or produced from low pressure steam compressed into a smaller volume by external force; thus it appears that a higher temperature in the heat absorbed in forming the steam produces the same effect as the application or transfer of energy from without in giving density and pressure. Therefore, the condition, or quality of the heat, should be considered in these investigations as well as the quantity.

Latent heat may be conceived of as a kind of polar arrangement of the particles of an elastic fluid, the angular distances of the like atomic poles increasing and decreasing with the distances of the particles from each other. The amount of latent heat which a liquid takes up in changing to a vapour is always proportional to the pressure, and the pressure is obviously as the space in elastic fluids, so that by increasing the pressure the apparent step between the two states of liquid and vapour is made smaller and smaller. The quantity of heat, or molecular motion, appears to be constant in the change of state independent of temperature or space. Therefore when vapour is formed at a low temperature, and corresponding low pressure, we may imagine the energy from the fire to actuate the particles in large orbits with few vibrations in a given time, and the like atomic poles greatly averted, consequently low repulsion; and, on the other hand, when vapour is formed at a high temperature, and corresponding high pressure, the same amount of communicated energy may be supposed to actuate the particles in smaller orbits with a greater number of vibrations in the same time, the angular distances of the like atomic poles being smaller, and, consequently, increased tension, or repulsive, force in the fluid. By some such hypothesis we can conceive the amount of thermometric heat in a given weight of saturated steam to remain constant under all changes of pressure and temperature, while the molecular repulsion, or calorific energy varies with the circumstances.

On a superficial view of the phenomena it might be imagined that, because the quantity of thermometric heat is the same in steam of various pressures, the increase of energy in high pressure steam costs nothing. Commercially speaking such is nearly the case, but in nature's laboratory everything must obey the laws of equivalence in phenomena of this kind, and there can be no doubt that the increased energy of the high pressure steam is produced by the transfer, or transformation, of some equivalent energy sent in from the fire; but as the temperature of common combustion is enormously higher than that of ordinary steam, and the temperature communicated to the liquid particles in becoming vapour is only the actual temperature of the steam, the *energy of concentration*, or high temperature in the heat, is availed of only in a very limited degree, and the greater part of it is allowed to run down and become diffused without producing the amount of dynamical effect which would result if it could be transmitted to the forming steam at a higher temperature.—J. Gill.

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Obituary.

MR. BENJAMIN GOODFELLOW.

We regret to have to announce the death of Mr. B. Goodfellow, on the 29th of April last.

Mr. Goodfellow held a leading position in Hyde, and the neighbourhood of Manchester, during the last twenty years. He will be well known to most of our readers as one of our leading mechanical engineers, and by his numerous inventions affecting the various branches of engineering. He attained the high position which he held by dint of unremitting energy and industry.

Mr. Goodfellow was born of very humble but industrious and exemplary parents, at Rainin, a village in Macclesfield, in 1811. He commenced working in a silk mill at the age of six years—and after the removal of his parents to Hyde, he worked at the Carrfield Mills, Floweryfield, until 1838, during which time he worked upon all the machines needed in the manufacture of woollen cloth, and finally was employed as a mechanic, working upon the various machines used in spinning and weaving cotton.

In 1838 Mr. Goodfellow invented and patented his well-known metallic piston, the novelty of his invention consisting in the employment of three spring rings, producing both a vertical and a lateral action at the same time.

About the time of patenting his metallic piston, Mr. Goodfellow commenced business as a maker of them on his own account, at the Carrfield Mills, the use of the mechanics' shop being granted him by the proprietor of the Mills—the late Mr. Thos. Ashton.

He remained at Carrfield Mills about two years, and then removed to the site of the works on Mottram Road, where he gradually embarked in all the different branches of mechanical engineering, extending his works almost year by year since 1848 (in which year the chief portion of them was built) until they now stand on about 20,000 square yards of land, and when times are prosperous above 400 men are employed upon them.

THE RE-OPENING OF THE COLOSSEUM.

The Colosseum, with its numerous attractions, has been recently re-opened to the public under the management of Mr. J. Nimmo. During the time the building has been closed for the purpose of repairs, &c., advantage has been taken of the opportunity, to re-embellish the whole of the interior. The new management has been inaugurated by an attractive programme. It is announced that the present will be the last season of the exhibition of the moving cyclorama of the destruction of Lisbon by earthquake, and of the great pictures of London by day, and Paris by night.

NON-CONDUCTING COMPOSITIONS.

Mr. James Spence of Her Majesty's Dockyard, Portsmouth, has patented some excellent and very effective compositions, suited for covering steam boilers, cylinders, steam pipes, and other heated surfaces, for retaining the heat and preventing radiation.

As a substitute for the hair-felt lagging, &c., it is cheaper, and unlike hair-felt, it will perfectly withstand the highest temperature to which, by the introduction of the superheating of high pressure steam, the outer shells of boilers are now subjected.

By a variation in the proportions of the materials employed, Mr. Spence adapts the character of the composition to the various purposes to which it may be usefully adapted, whether for retaining heat, or excluding or resisting intense cold.

It has been tried with perfect success for several months, during which time we have had the opportunity of judging how admirably it is suited for the several purposes to which it has been applied; and, by its substitution for the present method employed for covering steam boilers in her Majesty's service. Not only will a great money saving be effected in first cost, and for renewals, but the danger arising from risk of fire will be avoided.

MR. RICHARD ROBERTS, C.E.

Messrs .Moira and Haigh, of Lower Seymour-street, Portman-square, have produced an admirable likeness of Mr. Roberts, of Manchester, and Messrs Marion and Co., of Soho-square, are the publishers. As a specimen of photographic art, it is excellent, and will doubtless be highly appreciated as a faithful likeness by all the friends of the worthy and highly talented original.

TWIN-SCREW OR DOUBLE-SCREW STEAMSHIPS.—At the Royal United Service Institution, Captain T. R. Symonds, R.N., on Monday, the 18th of May, read a paper upon the advantages of manœuvring ships of war with broadside guns in action by means of two screws, worked by separate and independent engines, and compared it with the cupola system. The construction of ships, and the mounting and disposing upper deck guns of large calibre, proposed by Captain Symonds, enables fore and aft firing to be performed more perfectly than in any arrangement previously brought to the notice of naval artillerists, and, with the aid of the two screws, secures advantages not possessed by either the cupola system or any other plan of arming ships.

NOTICES TO CORRESPONDENTS.

PATER.—In answer to your enquiry, the Admiralty order to which you refer is very explicit as to the points. For your information we give the points *in extenso*:—

Engineer Boys and Dockyard Apprentices.

1. The vacancies for these appointments are open to public competition.
2. Candidates must not be under the age of thirteen years and nine months or above the age of fifteen years on the first day of the month after the examinations. Proof of age will be required by certificate of birth, extract from baptismal register, or declaration before a magistrate, which must be produced at the time of the examination. They must also produce evidence of respectability on a form which will be furnished by the superintendent. They will not be admitted for examination unless their age is within the above limits, and until they have been pronounced fit for her Majesty's service, by the medical officers in the yard, and they should possess the following qualifications at the minimum age:—

Height	4ft. 8in.
Weight	90lbs.
Girth of Chest	26in.

but a deficiency in these requisites will not exclude a candidate who may be pronounced by the medical officers to be generally calculated to make efficient workmen.

3. Examinations will be held in January and June.
4. The following will be the subject of examination, and the maximum number of marks for each subject:—

Arithmetical	350
Spelling	100
Handwriting	100
Reading	100
Grammar	100
English Composition	100
Geography	100
Euclid, 1st three books	150
Algebra, up to, and including quadratic equations; arithmetical and geometrical progression ...	150
Total	1250

5. A competent knowledge of the first four subjects will be required of all candidates, and candidates for the factories must also possess a competent knowledge of the first three books of Euclid, to render them eligible for appointment as engineer boys. The other subjects will count in the competition, but will not be considered essential.
6. 200 marks as a maximum will also be given for physical qualifications, viz., —height, weight, girth of chest, and strength.
7. The boys will be appointed according to their standing on the examination list, and the successful candidates will have the option of choosing vacancies for engineer boys in the factories, or for apprenticeship in the dockyards.
8. Candidates who fail at the first examination will be entitled to a second, if not over age.
9. All apprentices entered in future in the Master Shipwrights' Department, except millwrights, will be employed during the last two years of their apprenticeship, or part of that time, on board Her Majesty's sea-going ships in commission. They will receive their dockyard pay, with an additional day's pay per week for Sundays, and will be victualled on board, and receive tool money.
10. Apprentices receiving a superior course of instruction, if sent to sea, will be allowed to continue their studies under the naval instructor.
11. On the expiration of their period of service they will receive a certificate of their character and conduct, the progress they have made in their trades and in the knowledge of the subjects prescribed for dockyard apprentices. If this certificate be favourable it will receive due consideration, when any of these young men shall be candidates for promotion, either as carpenters' mates, or as inferior officers in the dockyards.
12. The apprentices now in the service will be allowed to avail themselves of these regulations on the recommendation of the Superintendents.
13. The engineer boys are not *apprenticed*, but are admitted to the factories for a period of about five years, with a view of becoming naval engineers should they, on examination, be found properly qualified, and should their services be required.
14. The list of candidates for the factories and for apprenticeship, is kept by the Superintendents of the dockyards, to whom all applications must be addressed. Persons serving afloat must apply through their commanding officers.

S.H.—Sketch received, and will be noticed in our next.

Z. C. AND OTHERS.—The water jet propeller may be seen daily on the River Meuse, and, we believe, also on some part of the Elbe. The plan there used differs from Ruthven's. Experiments are being conducted on some of the French canals with vessels having longitudinal trunks or water ways, through which the water admitted at the bows is ejected at the stern with considerable force, by means of rotary pumps.

BUILDERS' MEASUREMENT, &c.—You will find what you require in the "Rudiments of Naval Architecture," by Peake, price 3s. (Weale's series), and "The Theory and Practice of Shipbuilding," by T. White, price 16s.; also by Weale, High Holborn; and, if you apply to Messrs. Spon, of Bucklesbury, they will forward you a series of books upon shipbuilding, and the various rules relating to measurement, &c.

J.H.—The pipe joint we should recommend for the purpose is that recently patented by Dr. Normandy, which effects a thoroughly tight joint. Should you use iron piping the same joint could be employed.

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RECENT LEGAL DECISIONS
AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Oppenheim v. Fry.—This was a case tried in the Court of Queen's Bench, which raised an important point in the law of marine insurance,—whether the machinery of a steamer should be deemed part of the vessel, so as that the expense of putting out a fire in the hull should be recoverable as general average on machinery and hull, or be chargeable only against the hull. The policy was upon a steam vessel, valued at £22,000—that is, £14,000 for the hull and £8000 for the machinery—and the sum insured was £17,650; "average payable on the whole, or each, as if separately insured," 3 per cent. The steamer went to Constantinople, and while lying there near the shore a fire took place, which communicated to the hull of the vessel; and the sum in question was the amount of expense incurred in putting out the fire, which did not damage the machinery. When the owners came to claim upon the policy, the "average stater" stated the "particular average" at £386, in which, however, was included a sum of £9 for fees to Lloyd's surveyors for survey of the damage before the repairs; and, deducting that sum, there would be only £377. The other sum in dispute was thus stated as "general average." "Sundry expenses incurred in putting out the fire in order to preserve the ship from total destruction, employment of labourers, &c., £55," of which £35 was agreed to be the amount allotable to the hull, if it was a general average. The sum of £9 was stated as "particular average." Now, deducting the £9 from the £386 would leave £377, and adding thereto £55, would make a sum of £432, which would be, it will be observed, more by £12 than the amount of 3 per cent. on £14,000, the value of the hull. The average stater, however, stated the £55 as general average, out of which, in that view, only £35 out of the £55 would go to the hull; and adding this to the £377, would make up the sum of £412, which would be less by about £8 than the amount of 3 per cent. on the £14,000. The question in dispute (said to be important in point of principle) was, first, whether the £9 was particular or general average, and, next, whether the whole of the £55 should be allotted to the hull alone and be deemed particular average, so as to raise the sum above 3 per cent. A certain sum had been paid into court by the underwriters, and the question was if that was enough. If the amount in dispute were appropriated to general average, then the loss would be under 3 per cent., and the sum so paid would be enough; if to particular average, then the loss would be above 3 per cent., and the sum paid would not be enough. The case was tried at Guildhall, before the Lord Chief Justice, and the facts not being disputed, the question of law was reserved for the Court. The Court thought that the plaintiff was not entitled to calculate more than £35 of the £55 as particular average, and was not entitled so to calculate the £9, the expense of the survey, for the rest of the £55 and the sum of £9 were expenses incurred for the safety of the entire vessel. Thus, therefore, the loss would be under 3 per cent., and the plaintiff was not entitled to recover more. Judgment for the defendant.

NOTES AND NOVELTIES.

OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts, Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

MISCELLANEOUS.

Iron Tank Oil Ship.—The *Ramsay*, an iron tank-ship, built for the Petroleum Trading Company, recently sailed from Liverpool for New York. This vessel will carry about 400 tons of petroleum in tanks, and an equal quantity in barrels, and the system is so much approved by the underwriters that insurances can be effected on her at less than half the usual rates.

New Fortifications.—The annual return relating to expenditure on fortifications states that the £2,000,000 authorized by the Act of 1860 have been raised, and £70,000 of the £1,200,000 authorized by the Act of 1862. These sums have been obtained by the creation of terminable annuities (1855), amounting to £133,827. The annuities were calculated at 3¼ per cent. interest. The amount actually expended up to the 31st of March last is as follows:—At Portsmouth, £764,729; at Plymouth, £393,870; at Pembroke, £134,975; at Portland, £122,134; at Gravesend, £78,463; at Chatham, £122,242; at the Medway and Sheerness, £125,463; at Dover, £190,718; at Cork, £21,493; on experiments, £1,318; land surveyors' charges, £10,414; surveys and legal expenses, £35,465; officers, surveyors, clerks, draughtsmen, &c., employed, and contingent expenses, £40,165. Total, £2,041,449.

Subterranean Forest.—During the progress of the Victoria Dock extension works at Hull, a subterranean forest has been struck at a depth of 32ft. from the surface. In one instance the root and part of the stem of an immense oak, about 20ft. in circumference, and in a good state of preservation, lies exposed, and, as it is on a level with the bottom of the dock, it will probably continue in its original position until the end of time. The remains of the trunks of two other large trees have also been dug up, one of which bears the evident marks of fire. In some instances the wood is mixed with clay, and mostly as black as ebony, and when cut by the workmen's spades, soon crumbles into dust by the action of the air. The forest appears to have been of a very great extent, for at present no limit has been found to its boundaries. Wherever the excavations are continued, the workmen discover traces of its existence. It may not be uninteresting to describe the geological condition of the strata. Clay is found to about 15ft. below the surface, and beneath that a seam of sand, which is followed by a stratum of sand of a moister nature, greatly mixed with cockle and other fresh-water shells, and then comes the seam containing the wood, wetter still.

Tin Lined Lead Cisterns.—At a meeting of the Liverpool Chemists' Association on the 7th ult., specimens of lead pipe and sheet lead, electro-plated with tin, were exhibited by Mr. Holt, and some discussion ensued respecting the use of lead coated in this manner for water cisterns and pipes. It appeared to be the opinion of the meeting that the coating of tin, instead of preserving the lead, was far more likely to insure its more rapid corrosion, for if the coating of tin by any means happened to be scratched off, even to the slightest extent, galvanic action would take place, and the lead would be destroyed very quickly. Dr. Nevins and Dr. Edwards stated that their experiments had proved that such would undoubtedly be the case, Dr. Edwards remarking that, in one case which he had examined, a cistern made of lead, in which was an accidental admixture of tin, was eaten out by well water in six months, the lead being rapidly precipitated in the form of sulphate, &c.

Paris to be Lit by Electricity.—The lighting of Paris, it is stated, is to be entrusted to M. J. Von Malderan, who has invented a new electric light, one jet of which is equal to 2200 jets of gas. The Place Saint Surplice is destined to be the first where the essay is to be tried.

Trial of an Hydraulic Press.—The official trial of Messrs. Westwood, Baillie, and Co.'s new 28in. hydraulic press, erected in Woolwich dockyard, for bending and preparing armour-plates took place on the 19th ult. The first test consisted of a trial of two 4½in. armour-plates, made hot, forming a thickness of 9in. of solid iron, which were placed in the press and bent to a curve of seven-eighths in the breadth of the plates in less than five minutes, at a pressure of 1000 tons on the whole surface of the piston, the pump making about 130 revolutions per minute. In the second trial the plates were adjusted so as to bring the pressure near the centre of the plate. The pump was then worked up to about 1539 tons by indicator, bending the two slabs of iron to a curve of one half in their breadths. The third and last trial consisted of a simple test of the working of the pump and the strength of the press. The pump worked up to about 1600 tons and exhibited no visible signs of weakness. The press is fitted with an improved apparatus—namely, a table or guide at the top of the cylinder to keep it from rising or canting, which will enable it to be worked up to the enormous pressure of 2000 tons. The Russian Government have desired Messrs. Westwood and Co. to supply three of these presses with the utmost possible despatch, after having investigated the capabilities of the press by a careful inspection during its erection in Woolwich dockyard.

Anti-Fouling Compositions for Iron Ships.—The difficult problem of discovering a mode through which the bottoms of iron ships shall be entirely preserved from fouling has been but little advanced by the experiment lately completed at Devonport. The premium offered by the Lords of the Admiralty for producing the long-desired preventives continues, therefore, open to competition. The iron-screw steam tender *Minx*, of 303 tons, which has engines of 10-horse power, commanded by Mr. James Pook, does harbour service for the Channel fleet, and supplies the ships with water. She received last September on her port side amidships three samples of different compositions, each 10ft. wide, and extending down to the bottom of the keel. The sample forward was that manufactured by Mr. Fidemore, the next was that supplied by Mr. Elsworth, and the third was a preparation recommended by Mr. Edwards, assistant-master shipwright in Devonport dockyard. The remainder of the port side forward and aft, and all the starboard side, received the composition of Mr. Hay, chemist, of Portsmouth. So prepared, the *Minx* was floated on the 10th of October, 1862, since which time she has been constantly occupied on harbour duty. Ships so employed foul much more speedily than those making long voyages. After three or four months' experience, it was found that sea-weed and grass had grown considerably on the port side of the *Minx*, which made her very "unhandy with her helm." Recently she was placed high and dry in dock, and an opportunity was given for examining her bottom minutely. There is considerable difference between her draught when laden with water, provisions, &c., as a tender, and when in ballast; and as she had been mostly in one or other of these conditions during the last seven months, the load line and the ballast or light line are marked most distinctly all round. Between the two there is not much vegetation, but on the lower line, where the compositions of Messrs. Finemore and Elsworth are laid on, there is a distinct fringe of weed two feet long. Below the fringe in the former, light sea grass, small barnacles, and much rust prevail. On Elsworth's composition there are barnacles and thick grass, but very little rust. On Hay's composition there are some weeds, many small barnacles, but very little rust. Before this preparation was laid on a coat of bitumen was applied to the iron. The test applied to the *Minx*, according to the present trial, places Mr. Hay's composition first, Mr. Elsworth's second, and Mr. Finemore's third, in order or success.

Messrs. Gwynne and Co. have, we understand, received orders from the Admiralty for the supply of the pumping engines for the new docks at Malta (their patent centrifugal pump is to be used), and of a capacity capable of discharging 35,000 tons of water in four hours. Messrs. Gwynne and Co. have also in hand a pair of engines, with the centrifugal pumps for the dry-dock of Messrs. Palmer Bros., ship-builders, Newcastle-on-Tyne, and one to discharge 240,000 cubic feet of water in three hours, for the new floating dock for the Dutch Government now being constructed in Holland, &c.

Petroleum.—Messrs. Booth and Garrett, professors at Philadelphia U.S., have found that 2·599 gallons of petroleum oil produce as much light as 1000 cubic feet of coal gas, or 11·699 gallons of a mixture of turpentine and alcohol. For the price of the petroleum as compared to other lighting substances, the following return was made:—

	£	s.	d.
A quantity of light produced by spermaceti candles, cost	4	3	4
" " by adamantine	2	11	5½
" " by paraffin oil	2	8	8
" " by coal gas	0	8	9
" " by petroleum		4	5½

Owing to the cheapness of the petroleum oil, it is at present also employed as fuel in America. Thus an oil refiner of Erie uses it in place of coal, by leading it in the required quantity to the furnaces through a tube. By this means he realises an economy of £4 per week. As soon as means will have been found of removing the unpleasant smell petroleum spreads during the combustion, its use will become infinitely more extensive.

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AN INTERNATIONAL EXHIBITION OF AGRICULTURAL MACHINERY will be held at Koenigsberg, Prussia, from the 24th to the 39th of August, 1863, in connection with the agricultural and horticultural gathering, intended exclusively for Prussia. Manufacturers of all countries are admitted to competition. The awards will consist of medals and diplomas. Several of the exhibited machines will be raffled for at the close of the exhibition. Most of the German railway companies have granted a reduction in the rates for transport of machines to be sent to the exhibition. Forms (which must be filled up and sent in before the 15th of June), and information may be obtained from the Secretary General.

AN INVENTION IN PHOTOGRAPHY has been made in Berlin. From the experiments of Herr Heckert, it will be possible henceforth, it is said, to burn photograph into glass. Herr Toelken, the secretary of the Royal Academy of Arts, speaks in high terms of the delicacy of the shades and the wonderful effect of light on a drawing of photograph correctness and abundance of detail. The first production of the new art will probably consist in transparent pictures, to be hung up against the window panes.

THE ALKALI WORKS REGULATION BILL.—The bill introduced by Lord Derby has been read a third time in the House of Lords. The title and provisions of the bill may be shortly stated as follows:—It is to be cited as the "Alkali Act, 1863." It is to come into operation on January 1, 1864. The term "alkali work" is to mean *every work in which muriatic acid is evolved*. Every alkali work is to be carried on so as to ensure, to the satisfaction of the inspector, the condensation of not less than ninety-five per cent. of the muriatic acid evolved. Any less condensation than this will make the owner liable to a penalty of fifty pounds for a first offence, and for every subsequent offence to a penalty not exceeding twenty pounds, nor less than two pounds, for every day the offence continues. All alkali works must be registered, and every change of ownership must be registered. The Board of Trade is to appoint inspectors to assigned districts. The next clause is important, as showing the wish of Lord Derby to ensure fairness in carrying out the Act. No land agent, nor any one engaged in any manufacture, or interested in any patent in or according to which the decomposition of salt or the condensation of muriatic acid may be effected, shall act as inspector under this Act. The inspectors may enter works at all reasonable times, day and night, without giving notice, but so as not to interrupt the process of the manufacture, to see that the provisions of the Act are carried out. The owners of the works, upon demand, are to supply the inspector with plans of those parts of the works (to be kept secret by the inspector) in which the salt is decomposed and the muriatic acid condensed. The inspector may make any experiments to ascertain the efficiency of the condensing apparatus, and the owner of the works is to give him all necessary facilities for the testing. All persons obstructing an inspector or refusing to give him the facilities incurs a penalty of £10 for every offence. The inspectors are to report to Parliament every year. Owners of works may, with the sanction of the Board of Trade, make special rules for the workmen attending to the condensing apparatus, and may annex penalties to the violation of such rules. The remainder of the Act refers to the recovery of penalties.

IMPROVED BORING MACHINERY.—The improvements which form the subject of the invention for which provisional protection has been granted to Mr. James Gilchrist, of Glasgow, have been designed with a view to obtain a more simple, convenient, and efficient arrangement of the parts than has hitherto been adopted. In one modification of the improved engine, the principal parts are fitted upon a framing, which is by preference mounted upon wheels. The parts comprise a steam boiler, winding details with actuating cylinder or cylinders, and a cylinder for imparting the required reciprocating motion to the boring rods; this last mentioned cylinder, which may be fixed or oscillating, is disposed horizontally, and its piston-rod actuates the vertical arm of a bell crank lever centred on a fulcrum, or on journals at a higher level than that of the cylinder, and having its other arm projecting horizontally outwards over the bore, and being connected to the boring-rods. The steam may have access to both sides of the piston, its action on both sides, or on one side only, being regulated by a suitable valve, actuated by hand or by the movement of the piston-rod itself; or the steam may be allowed access to only one side of the piston. The arms of the bell-crank lever need not in all cases be at right angles to each other, but may in some cases be arranged to suit a diagonal or inclined position of the actuating steam cylinder. When the boring-rods have to be drawn out of the bore, the bell-crank lever may be disconnected and turned out of the way.

PETROLEUM.—The importance of the trade in petroleum, or American oil, continues to increase at an unprecedented rate. The importations into Liverpool this year are stated in a circular of Mr. Macrae to have been more than 70,000 casks, against 8000 casks in the corresponding period of 1862, yielding in dock and town dues alone nearly £2000 for the four months.

JADE.—At the last sitting of the French Academy of Sciences, M. Damour described certain differences which existed between green and white jade, a well-known mineral which is brought over from Asia, under the form of vases, bracelets, hilts of daggers, &c., and which, according to our author, is a kind of tremolite. These two species of jade differ considerably from each other; the density of the white species being only 2·97, that of the green sort, 3·34; the latter is rather harder, a little more translucid, and of a slightly crystalline structure; its fracture is splintery, finely lamellary, and at times somewhat fibrous. Under the action of the blow-pipe it melts into a transparent glass, while white jade, on the contrary, is transformed into a dull white enamel. Both kinds resist the action of the nitric, hydrochloric, and sulphuric acids. A chemical analysis further shows that white jade is essentially formed of silica, lime, and magnesia, and therefore belongs to the family of the Amphiboles, while green jade belongs to that of the Wernerites, and the species called Dipyre.

NAVAL ENGINEERING.

THE IRON-CLAD FLEET.—A return has been issued, giving the names, tonnage, horse power, number of guns, dimensions, and other particulars of our iron-clads, with the dates when they were, or are expected to be, launched. Exclusive of the floating batteries, there are twenty-one iron clad vessels, eleven of which are building and will be launched as follows:—The *Valiant*, June, 1863; *Minotaur*, July, 1863; *Royal Alfred* and *Research*, August, 1863; *Prince Albert*, *Zealous*, *Royal Sovereign*, and *Achilles*, September, 1863; *Favourite*, January, 1864; *Agincourt*, March, 1864; and *Northumberland*, May, 1864. The ten launched are the *Black Prince*, *Warrior*, *Hector*, *Defence*, *Resistance*, *Caledonia*, *Ocean*, *Prince Consort*, *Royal Oak*, and *Enterprise*. The total tonnage of these vessels is 88,697, the number of guns carried 534, and horse power 18,060. Two of those building—the *Prince Albert* (2,529 tons, 5 guns, and 500 horse power), the *Royal Sovereign* (3963 tons, 5 guns, and 900-power)—are fitted with turrets on Captain Coles' principle; and three—the *Favourite* (2186 tons, 8 guns, and 400-horse power), the *Research* (1253 tons, 4 guns, and 200-horse power), and the *Enterprise* (990 tons, 4 guns, and 160-horse power)—are fitted with the turret on Mr. Reed's principle. There are seven floating batteries, carrying 106 guns.

THE TRIAL OF THE "BLACK PRINCE," 40, iron screw frigate, engined by Messrs. Penn and Son, took place at Portsmouth on the 22nd ult. Six runs were made with full boiler power at the measured mile, the mean speed of the six runs being 13·501 knots. The revolutions of the engines were, maximum, 54½, and the mean 53½. The load on the safety valve was 25lb., and the indicated horse-power 5309. The draught of water was 26ft. forward, and 27ft. aft. The propeller was a Griffiths of 24ft. diameter, 28ft. 6in. pitch, and 4ft. 10in, length. Two runs were made at half boiler power—six boilers, the mean speed of which was 12·221 knots, the revolutions of the engines being 47. The trials of steam having been concluded, the ship was next tried in making circles under full steam. With a starboard helm the full circle was made in 10 min. 3 sec., the half circle in 5 min. 20 sec., the angle of the rudder being 18 degrees, with two turns of the wheel, and the revolutions of the engines 48, having been 54 previously to commencing the circle. With a port helm the full circle was made in 10 min. 25 sec., the half in 5 min. 32 sec.; the angle of the rudder was 22½ degrees, the turn of the wheel 2½; and the revolutions of the engines 48. There were in both instances 12 men at the wheel. The speed attained by the ship was about one-tenth of a knot less than on her last trial. The time occupied in making the circles exceeds the average of our ships of war. She is steered by a screw over her rudder-head, but the lever arms of the screw are so confined in the rudder-head that the greater the angle is made with the rudder the less the power of the steering screw becomes.

THE "EMERALD," 34, screw frigate, Capt. A. Cumming, on the 8th ult. made her fourth experimental screw trial, at the measured mile in Stokes Bay, near Portsmouth. The ship's draught of water was, as nearly as possible, the same as on the three former occasions, being 20ft. 9in. forward, and 21ft. 10in. aft. The wind was at a force of from 2 to 3 from the south-east. The screw used on this occasion was one of four blades, the blades being set at equidistant intervals round a Griffiths boss. The mean of six runs made gave the ship a speed of exactly 12 knots, an extremely satisfactory result, and fully confirming those obtained with the same description of screws in the experimental trials of her Majesty's ship *Shannon*. In fact, it may be stated, that the four trials of the *Emerald* confirm the trials made with similar screws in the *Shannon*, and that so far nothing has been added to the knowledge we already possessed on the subject. It is expected, however, that the *Emerald* will conclude her series of trials with the leading corners cut off her four and six-bladed common screws, and with a two, a three, and a four-bladed screw of the Griffiths pattern. In making the circles on this occasion at the conclusion of the six runs at the measured mile, the *Emerald*, with the helm aport, made the circle in 7 min. and 9 sec., the angle of the rudder being 13½ degs., and revolutions of the engines 53. With the helm a-starboard, a full circle was completed in 8 min. and 22 sec., the angle of the rudder being 14 deg., and the revolutions of the engines 53½.

THE "CURAÇOA," screw frigate, made her official trial of speed on the 18th ult., at the measured mile in Stoke's Bay. Six runs were made at the mile with full boiler power, the mean speed of the ship being 10·750 knots. Four runs at half-boiler power gave the ship a mean speed of 8·670 knots. Circles were also made with the following results:—With full power:—Port helm—The half circle was made in 3min. 31sec. and the full circle in 6min. 46sec., the angle of rudder being 15 deg., the turns of wheel 2½, and the revolutions of engines 69½. Starboard helm—The half circle was made in 3min. 8sec., and the full circle in 6min. 15sec., the angle of rudder being 15 degrees, the turns of wheel, and the revolutions of engines, 68. With half power:—Port helm—The half circle was made in 4 min. 7 sec.; the full circle in 8 min. 22 sec., the angle of rudder being 19½ degrees, and the revolutions of engines 51. With half power:—Starboard helm—The half circle was made in 3 min. 52 sec., and the full circle in 7 min. 29 sec., the angle of rudder being 19½ degrees, and the revolutions of engines 51. The machinery, 350-horse power, by Maudslay, Field and Son, gave every satisfaction to the officials on board by its working.

PLATED FRIGATES FOR TURKEY.—Mr. Tucker, one of the superior officers of the shipwright's department of Woolwich Dockyard, has been ordered by the Board of Admiralty to proceed to Glasgow and survey the frigates (three in number) under construction by Messrs. Napier and Co. for the Turkish Government. The frigates will be built of iron, of the *Warrior* class. Two of the number are already somewhat advanced.

VENTILATION OF THE IRON-CLADS.—In consequence of the great success which has attended the newly-invented ventilating arrangements on board the iron-clad screw frigate *Royal Oak*, 35, Capt. Campbell, fitting for sea at Chatham, the Lords of the Admiralty have decided on introducing a similar system on board the other vessels composing the squadron of armour-plated steamers. Orders have accordingly been received at Chatham dockyard for one of the officials from Devonport dockyard to proceed to Chatham for the purpose of obtaining a knowledge of what has been done, with a view to their being applied to the armour-plated frigate *Ocean*, recently launched at Devonport. The system of ventilation carried out in the *Royal Oak* is from a plan submitted to the Admiralty by Capt. Fanshawe, superintendent of Chatham dockyard; the engine-room and stokeholes being ventilated according to the principles laid down by Mr. Baker, inspector of machinery, and the chief of the engineering department at Chatham.

A NEWLY-INVENTED ELECTRO MACHINE COATING is about to be applied to the plates of the iron-cased steam-frigates *Gloire* and *Invincible*. It appears that this new composition has been found to be very successful in the preservation of metals. The Minister of Marine has addressed a despatch to the several Port Admirals, instructing them to send a number of shipwrights to Paris, to be instructed in the preparation of this new composition.

NAVAL APPOINTMENTS.—The following appointments have taken place since our last, J. Roberts (a), Acting Chief Engineer; F. H. Herring, Engineer, J. Ambler and T. Carline, First-class Assist. Engineers, and W. Scott, E. J. Humphreys, and T. W. H. Ramsey Acting Assist. Engineers, to the *Orontes*; W. C. Beck, Engineer, to the *Cambridge*, for the *Redwing*; J. Blight, acting Engineer, to the *Indus* for the *Gleanor*; J. A. Tuck, Chief Engineer, J. Hill, Engineer, P. Richmond, acting Engineer, A. Martell, J. Clark and H. Darroll, acting Engineers, and H. W. Ross, and W. Ambler, acting Assist. Engineer, to the *Royal Oak*; E. F. Lucas, acting Assist. Engineer; to the *Asia*, as Supernumerary; R. Williams, Chief Engineer, W. W. Christie, Engineer, and C. R. Lacy, H. J. Wilson, J. Forrest, H. London, and W. Hallowell, Assist. Enginner, to the *Liverpool*; H. C. Jones, Engineer to the *Fisgard*, for the *Enterprise*; W. Inglis (b), First-class Assist. Engineer to the *Pantaloon*; C. B. Healey, Second-class Assist. Engineer, to the *Black Prince*; G. Rigby, Supernumerary in the *Indus*, promoted to First-class Assist. Engineer; A. M'Innes, Chief Engineer, to the *Geyser*; J. Ross, Engineer, to the *Indus*, for hospital treatment; J. Wyllie, and A. Moreton, Assist. Engineers to the *Valorous*: H. A. Henri, and G. Thompson, Engineers, to the *Indus*, for the *Tilbury* and *Nightingale* respectively; F. Day, Assist. Engineer, to the *Fisgard*, as supernumerary; J. Smethers, of the *Jackall*, J. F. Hattersday, of the *Edgar*, W. M'Glashan, of the *Electo*, P. Thompson, of the *Pembroke*, Williams, of the *Rhadamanthus*, and T. W. Cameron, of the *Princess Charlotte* promoted to be First-class Assist. Engineers; T. Marsh, of the *Orlando*, R. L. Owen, of the *Charybdis*, H. J. Packer, of the *Algerine*, M. Blunk, of the *Bacchante*, C. Wiggins, of the *Coromandel*, and J. B. Scarlett, of the *Encounter*, promoted to be acting First-class Assist. Engineers; J. Melrose, Assist. Engineer, to the *Mirror*; F. G. Gissing, in the *Asia* for the *Foam*, promoted to Engineer; T. W. Bower, Engineer, to the *Ajax*; J. Annable and J. Roberts (B), Assist. Engineers to the *Indus*, as Supernumeraries; H. J. Hall, Acting Second-class Assist. Engineer to the *Indus*; P. Butler, H. Wooley, and C. J. Incher, Engineers, to the *Columbine*, *Alert*, and *Leander* respectively; J. C. Grayand, and J. J. Rose, Assist. Engineers, to the *Columbine*; C. C. Hyde, and K. M'Caskill, Assist. Engineer, to the *Alert*; R. Bacon, Engineer, and E. Watson, Assist. Engineer to the *Geyser*; R. S. Lee, Assist. Engineer to the *Marlborough*; P. Colquhonn and J. Green, Acting Second-class Engineers to the *Orland*; W. H. Steil, Acting Chief Engineer, T. S. Grice First-class Assist. Engineer, and H. White (B) Acting Second-class Assist. Engineer

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to the *Cossack*; E. J. Murphy, First-class Assist. Engineer to the *Edinburgh*; J. A. Cooke Acting Second-class Assist. Engineer to the *Fire Queen*; J. Ward Chief Engineer, D. A. Campbell First-class Assist. Engineer, W. Harwood Acting First-class Assist. Engineer, and T. J. Andreworths, Acting Second-class Assist. Engineer to the *Esk*; G. Weeks Chief Engineer to the *Majestic*; E. Daniels Engineer to the *Cumberland* from the *Salamis*; E. Judge First-class Assist. Engineer, and F. Smiley Second-class Assist. Engineer to the *Cockatrice* R. H. Trubshaw Acting First-class Assist. Engineer, additional to the *Cumberland*, for the *Louisa*; D. B. Keiller Second-class Assist. Engineer to the *Caracoa*; R. Sutherland Second-class Assist. Engineer to the *Miranda*.

MILITARY ENGINEERING

Experiments at Shoeburyness.—These experiments took place on the 27th of April last. The target fired at was constructed at the Millwall Ironworks from the designs of Mr. Chalmers. The target was 13 feet long by 10 feet broad, faced externally with hammered armour-plates 3½in. thick. Behind these were laid longitudinal teak beams 10in. wide by about 5in. deep, a web or flange of wrought-iron ½in. in thickness passing between each beam, and being rivetted to a plate 1½in. in thickness at the back. Behind this plate again came another pad of teak 5in. thick, which rested against the skin of the ship—the same thickness as that of all our ironclads, ½ths of an inch, and behind this were the usual upright beams or iron ribs of the vessel. Thus it will be seen that, though the target was apparently a light one from its external plates being only 3½in. thick, yet in reality it had, after all, 5in. of iron in it, with 15in. of teak, exclusive of the longitudinal cellular iron webbing we have mentioned between the teak beams, which, though not nominally called upon to resist the shot, yet, in truth, aided the resistance enormously, by distributing the force of the concussion and giving great stiffness to the whole structure. The trial to which this target was subjected was precisely similar to that heavy ordeal which the *Warrior* target had to go through on the occasion of its *début* at Shoeburyness. The number of rounds fired, the guns, charges, and missiles were precisely the same on both occasions; but, as the target of Mr. Chalmers was nearly one-third smaller than that of the *Warrior*, the experiment was obviously more severe for the smaller target, as the fire had to be more concentrated The trials were gradually progressive in their attacking force from low charges, and shells filled with sand, up to solid 68-pounders, fired with the full service charges; 200-pounder solid cast-iron shot fired with low charges, then fired in salvoes of three at a time; and, lastly, simultaneous salvoes of three 110-pounders and two 68-pounders fired with full charges and solid shot. The live shell and shell filled with sand, as usual, effected very little, nor did the 110-pounder with 10lb. charge, nor the 200-pounder with a 10lb. charge do much more. The lower armour-plate of the three which composed the target was decidedly inferior to the two upper ones, and cracked badly early in the day. The method of fastening on the plates by 2½in bolts, with stopped conical heads and a square thread, contrary to general expectation, seemed to work admirably. Partly from the resistance offered by these bolts, and partly from the force of the concussion itself being so deadened and distributed, there was very little buckling out of the ends of the plates when struck even by the heaviest missiles. The dints in the armour plates made by the shot varied according to the weight of the projectile when rifled, and in no case were much to speak of. The 68-pounders, as usual, left a severe mark, in some instances nearly three inches deep. The salvoes of the two 68-pounders and three 110's were a severe trial. The five shots were concentrated on one spot, and struck with a terrific crash, splintering themselves to fragments. The main side of the backing—the skin of the ship, in fact—had, up to this time, been carefully examined after each discharge; for on the integrity of that under any fire depended, in fact, the success of the construction of the target. It had, however, shown no sign of yielding. Some three or four of the small rivet-heads had been jumped off, with one or two small bolts, and there was a just perceptible deflection of one or two ribs where great strains had come, but this was all. The armour-bolts all held firm, and the back of the target showed no sign that it had ever been fired at. One of the armour bolts was struck and the head knocked off at the back, and the ribs gave tokens of distress, but beyond this it was perfectly astonishing to see how well the target withstood the five ponderous missiles. The worst and most dangerous parts of the programme had been borne by the target with impunity, and, as it was wished to see how the backing would break, if it could be broken, Mr. Chalmers was asked to permit the 300-pounder rifled Armstrong, loaded with its formidable steel shot, to be used against it. The 300-pounder was accordingly loaded with a 45lb. charge, and sent its projectile completely through the target, leaving a large and ragged hole, though not so ragged as the same shot would have made in passing through armour plates backed up by teak in the common fashion. This destructive shot brought the experiments to a a close, the result of them being undoubtedly in favour of Mr. Chalmers's system of backing the plates, which is much superior to the plans adopted either with the *Warrior* class of vessels built, or the *Minotaur* class now building.

Testing Armour Plates at Portsmouth.—A testing of armour plates on the *Powerful*, old sailing line-of-battle ship took place on the 21st ult. The plates tested comprised one rolled, from Messrs. John Brown and Co., Sheffield, 15ft. in length, 3ft. 8in. in width, and 5in. in thickness. The Thames Ironworks sent two hammered plates of about the same dimensions as Messrs. Brown's The Mersey Works, Messrs. Clay and Horsfall's sent two hammered experimental charcoal-iron plates of about 5ft. by 3ft. 3in., and 5in. in thickness; and the Millwall Ironworks sent three of nearly the same dimensions, two of the three being rolled iron, and the third of steel. The practice was made as usual, under the superintendence of Capt. R. S. Hewlett, C.B., with a 95cwt. 68-pounder gun, and the distance was 200 yards. Messrs. Brown's plate received nine shot in one third of its length. One of the Millwall iron plates received eight shots, and the other seven. One of the Thames plates received eight shots, three overlapping each other, and four others being edge blows. All these plates were more severely tested than was the 5½-inch French plate that was recently tried at Portsmouth, and all passed the tests with considerably less injury to the metal than was inflicted on that plate. The second plate of the Thames Company was not of quite so good a quality as the first named, and the experimental steel plate of the Millwall Company broke up under the first shot. The The two plates manufactured by the Mersey Company were also easily broken up by the shot. It is necessary to state with regard to these two plates that the Mersey Company manufactured them at the request of a company in the iron trade, having a peculiar kind of charcoal iron, which they thought very suitable for armour plates, and which they desired to be tested. The result has, however, proved it to be utterly unfit for the purpose.

A Miniature Breech-loading Cannon upon a new principle, the invention of Mr. L. W. Broadwell, of New Orleans, U.S., was proved on the 22nd ult. at the experimental ordnance range at Woolwich, in the presence of the Select Committee of Woolwich Arsenal, and gave satisfactory results. The chief recommendations of the new gun are the remarkable simplicity of its breech-loading arrangements, and the solid and substantial method on which it appears to be constructed, as proved by its resistance of the severe test to which it was subjected on trial. The gun is on a small scale, for experiments only, and when brought out on larger dimensions will, as stated, prove a most serviceable weapon. No training is required to initiate the gunner, the method of loading being simply the removal and replacing of a small block of iron for the introduction of the charge. There is a self-acting expanding ring, which serves to seal the breach hermetically at the moment of discharge, and which does not impede the movement of the vent-piece. The projectile invented by Mr. Broadwell to be used with the gun is an elongated shot, and is simple and plain in construction.

STEAM SHIPPING.

Trial of an Anglo-Chinese Despatch Boat.—A very interesting trial took place on the 6th ult. at the measured mile in Stokes Bay, near Portsmouth, of the new paddle-wheel steamship *Kiang-Soo*, built by Mr. John White, of West Cowes, for the Emperor of China. This vessel is built on a diagonal principle. Her length is 241ft., breadth, 29ft.; depth, 15ft. 3in.; and tonnage, builders' measurement, 1000 tons. She is fitted with oscillating engines, constructed by Messrs. C. A. Day and Co., of the Northam Ironworks at Southampton, and has patent feathering paddlewheels. The diameter of the cylinders is 68in., with 5ft. stroke, and the velocity of the piston at full power 460ft. per minute. The *Kiang-Soo* left the Southampton Docks, where she received her engines and machinery on board, and steamed rapidly to Stokes Bay, where she was at once placed on the mile. and the result of four runs was as under:—First run, 3 min. 59 sec., equal to 15·063 knots per hour; second run, 3 min. 8 sec., equal to 19·149 knots; third run, 4 mins. 4 sec., equal to 14·754 knots; fourth run, 3 mins. 15 sec., equal to 18·462 knots; the Admiralty mean of the whole being 16·903 knots, or 19½ statute miles per hour. Revolutions of engines, 45; pressure of steam, 27lb.; vacuum, 26in. The engines, which are of 300 nominal horse power, worked up to 2,279. being over 7½ times their nominal power. The vessels mean draught of water was 9ft. 3in. At her highest rate of speed there was scarce any perceptible vibration, the machinery working with the greatest freedom, and she steered very easily. The boilers gave out an unlimited quantity of steam during the day. After the four runs were completed the vessels head was put to the eastward, and she ran rapidly through Cowes Roads, down the Solent, to the Needles, subsequently returning to Stokes Bay for a trial of her speed at half power. With only two boilers at work she traversed the mile in 4 min., or 15 knots per hour, and a second time in 4 min. 27 sec. or 13·483 knots, the mean of the two being 14·241 knots per hour, with the exercise of only half her steaming power; revolutions, 33; steam, 20lb.; vacuum, 27in. With such extraordinary results as these, the *Kiang-Soo* was unanimously pronounced by all the naval and scientific authorities present to be one of the fastest vessels afloat. The *Kiang-Soo* is intended as a despatch-boat for the Chinese navy, for the special personal use of Captain Sherard Osborne, the commander-in-chief of the Anglo-Chinese expedition.

The "Brighton," paddle-wheel steamer, belonging to the Weymouth and Channel Islands Company, having had new boilers and superheating apparatus fitted to her, underwent a trial at the measured mile, at Stokes Bay, on the 8th ult., when her speed was found to average 13 knots, or 15 statute miles per hour. The trial was pronounced in every way satisfactory.

The Esploratore.—On the second trial of the Royal Italian despatch vessel *Esploratore*, built by Messrs. Wigram, and fitted with engines of 350-horse power by Messrs. John Penn and Son, which took place recently, the speed was greater than on the former occasion. It was 17·26 knots, a gain of rather more than a quarter of a knot, or 20 statute miles per hour. The engines worked up to seven times their nominal horse power. With less than half the power of the Holyhead boats the *Esploratore* attained a greater speed.

Steamship Building on the Clyde.—Messrs. Tod and M'Gregor have entered into a contract to build a screw of 3000 tons for the British and North American Royal Mail Steam Navigation Company. The vessel, which will rank with the *Scotia*, *Persia*, &c., is to be named the *Cuba*. The *Artibonite*, just completed by Mr. Seath, for the Société Accélérée d'Haiti, has made a trial trip at the measured mile on the Garcloch. She is of 250 tons register, with engines of 50-horse power, capable of working up to 150-horse power effective; and at her trial she attained a mean speed of 11 miles per hour, being one mile above the rate specified in the contract, although the up runs were made against a gale of wind with the screw only partly immersed. Messrs. Scott and Co., of Cartsdyke, have launched a screw of 530 tons, named the *Vartry*, now being fitted with engines of 80-horse power by the Greenock Foundry Company. She has been designed specially for the transport of machinery and heavy castings.

LAUNCHES OF STEAMERS.

Launch of an Iron-cased Battery for the Russian Government.—The launch of the Russian iron-cased battery *Pervenetz* took pace on the 18th ult., at the Thames Ironworks and Shipbuilding Yard, Blackwall. The *Pervenetz* is a remarkable iron-cased ship of the following dimensions and tonnage:—The length between perpendiculars is 220ft.; the length of keel for tonnage, 188ft.; the breadth for tonnage, 53ft.; the depth of hold, 26ft.; and the burden, 2811 tons. In other words the length of the *Pervenetz* is only equal to four times the breadth; while our *Monitaurs* and *Warriors* are in length something like seven times her breadth. This is one of the points that distinguish the *Pervenetz* from the iron-cased ships we are constructing and converting. Another equally important point is that the sides of the *Pervenetz* are inclined at an angle of 27 degrees from the vertical; and the stem and stern, instead of projecting, as usual, above the load water-line, recede so as to relieve the ship from all possible top hammer at the extremities. Above the water, therefore, the *Pervenetz* is a ship constructed on the Jones' angulated principle, and not only are the sides angulated, but so are the extremities fore and aft. In such a structure there is considerable unsightliness at launching, but it will entirely disappear with the immersion consequent on completing the armour plating, the rigging, and the shipping of the armament and service stores. There is great displacement, light draft of water, top hamper reduced to a minimum by the sloping sides, and fore and aft fire. from the bow and stern, on a line with the keel. The engines, by Messrs. Maudslay, Sons, and Field, are of 300-horse power, capable of being worked to 500-horse power, so as, under favourable circumstances, to secure a speed of 9 to 10 knots an hour, or from 11 to 12 statutes miles. The armament on the main deck will consist of 28 68-pounders, or guns of greater calibre should such be desired; and on the upper deck there will be mounted four large pivot guns, We have given at another page illustrations and further descriptive particulars relative to this vessel.

Launch of an Iron-clad for Denmark.—The *Rolf Krake*, a cupola screw armour-clad man-of-war, built for the Danish navy, was recently launched from the building-yard of Messrs. R. Napier and Sons, on the Clyde. Her dimensions are—length over all 195ft.; breadth, 38ft.; depth, 14½ft.; engines, 240-horse power; tonnage, 1,246 tons. She is completely armour-clad from stem to stern, the plates extending for some distance below the water line. Her armour plates are 4½in. in thickness, increasing to 7½in. at the port-holes, with a backing throughout the hull of 9in. of teak. The cupolas or towers are built of plates outside, fixed on T-iron, and backed by 19in. of teak, the plates being 4½in. thick. These cupolas project 4½ft. above the upper deck, and are 21½ft. in diameter. They revolve on the lower deck, on which the gearing rests, and where they are easily turned either from the inside or from the outside. Her armament will consist of four 68-pounder guns, two in each tower, being worked inside and pointed by a gunner, who will take aim from a manhole in the grated roof. The same principle to ensure great strength has been carried out in building the *Kolf Krake* as in the *Black Prince* and *Hector*.

Launch of the "Salamis."—This vessel, designed by the master shipwright at Chatham, Oliver W. Lang, Esq., was successfully launched from Chatham Dockyard, on the 19th ult. The *Salamis* was laid down August 10, 1861; she is built upon the diagonal system, the wood used being mahogany, and it is calculated she will be one of the fastest steamers in the Royal Navy. Her principal dimensions are—Length between perpen-

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diculars, 228ft. over all; breadth, extreme, 28ft. 2in.; depth of hold, 14ft. 6in.; burden in tons, 834 50-94; horse-power, 250; she will carry two guns. The machinery is to be supplied by Messrs. Ravenhill, Salkeld, and Co. On the *Salamis* being brought up alongside the *Adder*, her draught of water was found to be forward, 4ft. 3in., and aft. 4ft. 6in.

THE "LORD GOUGH" was launched from the yard of Messrs. Caird and Co., on the 2nd ult. She is the property of the Dublin and Glasgow Steam Packet Company. Her dimensions are:—Length, 230ft.; breadth, 26ft., and depth, 74ft. 9in. She will be propelled with oscillating engines of 350-horse power.

TELEGRAPHIC ENGINEERING.

TELEGRAPHIC COMMUNICATION WITH AUSTRALIA.—Two projects are in the field for connecting Australia with Java. It is proposed to lay the cable on the north-west of Australia, on the shores of the Gulf of Carpentaria, or to take it round to Brisbae, the capital of Queensland. At this point the cable would be in communication with the existing intercolonial lines; and New South Wales, Victoria and South Australia would be thus brought into connection with the countries of the old world. The cost of laying the line from Java to Queensland is estimated at £1,000,000, but from Java to the north-west a cable could be laid for £243,000. Considering the many risks to which the submarine cables are exposed, und the uncertainty of their action, their can scarcely be a doubt as to the policy of selecting the cheaper route. The cost of such a land line has been estimated at £120 per mile, or for the whole distance from the north-west coast to Ade. laide a sum of £177,000, which would make together a sum of 420,000, as the cost of the complete system from Java to Adelaide.

RAILWAYS.

PARIS, LYONS, AND MEDITERRANEAN RAILWAY.—It appears that in the course of 1863, the administration devoted to the traffic service 106 new locomotives with tenders, of which six only were for the transport of passengers, the remaining 100 being required for goods. The rolling-stock of the company was also increased last year by 104 passenger carriages, and 5611 goods trucks of various models, principally, however, coal trucks. The orders now in course of execution, and which will be carried on in whole or in part in 1863, are 111 locomotives and tenders, 190 passenger carriages, and 1700 goods trucks. A part of this plant is constructed in the company's own workshops at Ouillens. The traffic of this system is immense. The receipts are now close upon £130,000 per week, and there can be little doubt that the revenue for 1863 will approach, if indeed it does not exceed, a total of £6,500,000 In 1862, the receipts increased £400,000 as compared with 1861; and in 1861, they advanced £1,000,000, as compared with 1860.

THE SOUTH AUSTRIAN AND LOMBARDO-VENETIAN RAILWAY.—This great work now includes 1482 miles, and 440 miles more are yet to be completed. The company carries on a foundry of its own at Gratz, and makes all its own rails and other heavy ironwork at a very reasonable cost. On the Venetian lines all that remains to be constructed are the station at Venice, the bridge over the Piava, and the line from Padua to Rovigo. The whole of the Lombard lines will be at work this year with the exception of the short piece from Gallaratta to Calendo, which will be completed in the spring of 1864. As to the Central Italian branch, the second section is to be opened in the course of the autumn, and the remainder in the autum of 1864. The total traffic receipts amounted for the year 1862 to £2,621,024; the expenses to £991,635, showing a surplus of £1,629,399, being an augmentation over the receipts of 1861 of £73,670. Adding the surplus to the balance from the preceding year and the interest on investments, the available sum will be £1,749,439, out of which the allowance for the sinking fund and interest on the loans must be deducted, leaving a balance equivalent to a dividend of 34s. per £20 share for the year 1862. The total capital received to the 31st of December last, amounts to £26,160,000; three-fourths of the company's lines have been opened for traffic; a dividend at the rate of 10 per cent. per annum, on the average has been distributed during the past four years among the shareholders, and the interest on loans has been paid out of the profits of working the open portions of the lines in course of construction; the profits on exchanges and the interests on investments, with the exception of about £800,000 which was, as usual, charged to capital, being only about 3 per cent. of the total expenditure on capital account.

EASTERN OF FRANCE RAILWAY COMPANY.—At the close of the year 1862, the rolling stock of this company comprised 614 locomotives of various systems, 501 ordinary tenders, 25 tenders on the Engorth principle, 1582 passenger carriages, 11 Imperial carriages, and 11,190 trucks of various descriptions. This stock was increased last year by the delivery of 313 additional goods trucks. The administration has ordered 21 locomotives, 12 tenders, and 84 trucks, which will be delivered in the course of the present year.

IMPROVEMENTS IN RAILWAYS.—A new economic permanent way, designed by Mr. G. F. Griffin, is attracting attention. The sleepers are made of currugated cast-iron, and the cost per mile is stated at £1245 against £1806, or £1844, under the existing systems. Apart from saving in annual maintenance, Messrs. Brassey, Betts, Trevethick, and others have given very favourable opinions of its qualities, and an experimental portion laid down about 15 monihs ago on the Great Northern line is stated to have shown most satisfactory results.

NEW RAILWAY IN RUSSIA.—It is understood that a new railway line, in connection with the Riga and Dunaberg lines, is about to be brought out, with a capital of £2,500,000.

NEW RAILWAY CARRIAGES IN FRANCE.—A trial is being made on the Eastern Railway of some new carriages which will, it is expected, remedy many inconveniences long complained of. A passage in the centre communicating with one compartment to another enables the railway officials to see what is going on during the progress of the train, and allows the passengers to freely move about from one end of the carriage to the other. A platform or balcony for smokers is placed at one end. Ventilators are also fixed, which can be opened or shut at pleasure so as to give a supply of fresh air. The new plan appears to present the following advantages—security, facilities for smoking without annoyance to anyone, and exemption from danger of fire, as the carriage is constructed of sheet-iron.

RUSSIAN RAILWAYS.—It is now understood that a new Russian railway line, in connection with the Riga and Dunsburg, is about to be brought about, with a capital of £2,500,000.

THE BHORE GHAUT INCLINE.—The construction of the Bhore Ghaut Incline, now completed, has occupied more than seven years, and during the greater part of that time there have been 45,000 workmen daily employed upon it. The incline is a series of tunnels through mountains of rock, and viaducts stretching across valleys, alternating with each other, each part a triumph of modern science and skill; the *ensemble*, stupendous in virtue of its magnitude and stability. Some of the grandest embankments have been raised up within the last few months—some, in fact very recently. These necessarily require heavy rains to settle and soldify them. As a matter of course they will sink many feet in the next rains. This will render the use of the incline impossible during the first monsoon. Until the rain actually falls, however, any amount of traffic may safely flow up and down the line, and after the approaching rains no serious interruptions, will occur on the incline. The measures of safety that have been adopted are such as to secure it, in so far as it possible for man to do so. The formal opening of the Incline by the Governor of Bombay took place on the 21st April, at Lanowlie, the top of the Incline. In THE ARTIZAN of October, we gave a copper-plate engraving of one of the powerful locomotives, specially designed by Mr. Kersham, for working on the of the India Peninsular Railway. We also gave some further details and particulars as to the gradients, &c.

RAILWAY ACCIDENTS.

ACCIDENT ON THE SOUTH WESTERN RAILWAY.—On the 12th ult., a serious accident occurred between the Wilton and the Dinton Stations on the South Western Railway. The up luggage-train arrived at Dinton Station shortly before nine o'clock a.m., and was allowed to go on. The ordinary mixed train also left Salisbury at eight o'clock, and was despatched by the station-master of the Wilton Station. There is a double line of rails between Salisbury and Wilton, but from that point to Dinton it is single, the additional line not being completed. The consequence was that the two trains came violently into collision near Hurdcott. The speed of each train was very much diminished; but the two engines ran into each other. There was between thirty and forty passengers, and all were more or less injured.

BOILER EXPLOSIONS.

MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.—At the ordinary monthly meeting of this Association, held on April 28th, 1863, the chief engineer presented his monthly report, of which the following is an abstract:—"During the past month, there have been examined 288 engines and 406 boilers. Of the latter, 6 have been examined specially, 11 internally, 79 thoroughly, and 310 externally; in addition to which 2 of these boilers have been tested by hydraulic pressure. The following defects have been found in the boilers examined:—Fracture, 5 (1 dangerous); corrosion, 30 (1 dangerous); safety-valves out of order, 1; water gauges ditto, 8; pressure gauges ditto, 9; feed apparatus ditto, 1; blow-out taps ditto, 32; furnaces out of shape, 4; over-pressure, 4; blistered plates, 4—Total, 98 (2 dangerous). Boilers without glass water gauges, 6; without blow-out taps, 13; without back pressure valves, 21. Three explosions have occurred during the past month to boilers not under the inspection of this Association, by which nine persons were killed and four others injured. All of these explosions occurred so far from Manchester, that only one of them—viz., No. 8, which was by far the most important—has been personally investigated. No. 8 Explosion.—This explosion occurred at an ironworks, and is one of the most remarkable that have come under the notice of this Association—five boilers, working side by side, having in this instance exploded simultaneously, the shells of all of them being rent asunder, and thrown to a considerable distance from their original brickwork seating, which was completely destroyed, and reduced to an unintelligible heap of ruins. The fragments and boiler fittings were shot in every direction, many of them falling through the roofs of the adjoining buildings, and one through that of the dwelling-house of the proprietor. Two of the boilers were thrown over a tramway, and landed in a ploughed field beyond; one of them raking the rails in its course, cutting them completely through at the solid metal, and tearing up the roadway, a piece of one of the rails, that had been shorn off, being carried away to a distance with the boiler. There was a strong tendency to impute this explosion to the action of explosive gases, or to the instantaneous generation of steam, from red-hot plates; since it was thought, that steam of the ordinary working pressure was quite inadequate to produce the results developed. These views are always revived on the occurrence of every serious explosion; and although chimerical, still have an importance, though a most unfortunate one, from the fact, that they tend to divert attention from the simple cause of the disaster, while they throw an air of mystery around the subject, which at once arrests all sound investigation, and thus destroys the chance of one explosion becoming the means of preventing the occurrence of others. If, however, at any boiler explosion, the existence of an agent more subtle and destructive than steam ever appeared probable, it certainly was in the present instance. Still, a little investigation will show to how simple a cause the whole may be traced, and though great as was the havoc, there is no need for the supposition of any force beyond that of steam at an ordinary working pressure. To do this, it may be well to enter more into detail as to the general arrangement, construction, and fittings of the boilers, as well as into the position of the fractures, and flight of the parts. The five boilers were ranged side by side, all of them being connected, both by the steam-pipe and feed-pipe. Their direction was very nearly north and south, the furnaces being at the south end. No. 1 boiler, commencing at the west, was of Cornish construction and internally-fired, while the remaining four were cylindrical, with egg-ends, and externally-fired. The length of all the boilers was about 25 feet, while the diameter was 6 feet in No. 1, and 5 feet in the remaining four, the thickness of the plates being seven-sixteenths in the former, and three-eighths in the latter. The boilers were each fitted with one feed back-pressure valve, and feed stop-valve combined, one glass water guage, one alarm low-water steam whistle, worked by a float fixed inside the boiler, and one lever safety-valve, of 4 inches diameter, in addition to a Bourdon's pressure-gauge fixed on the steam-pipe at some distance from the boilers. The safety-valve admitted of a pressure of nearly 60 pounds per square inch, but it was stated that 45 pounds had been the limit at which the boilers had been worked, since the weight had always been placed at some distance from the end of the lever. Even the higher pressure, however, would not have been excessive for boilers of such dimensions, as far as the cylindrical shells are concerned. The rents were extremely complicated by the effects of the explosion, and although highly important to do so, it is in these cases difficult to determine which are the rents from which the explosion sprung, and which are those that resulted from it; or otherwise, which are the primary ones, and which the secondary. It appeared, however, that all the egg-ended boilers had rent in two, transversely, one portion flying northward and the other southward, the rent occurring at one of the transverse seams over the furnace, while the larger portion had in every instance flown northwards. In some cases both ends were blown out, and the plates 'vandyked,' and curled up, the distortion being such as is difficult to describe. The Cornish boiler was also rent transversely, at about the middle of its length, both through the shell and flue tube, the end furthest from the furnace being demolished, the shell being opened out, ripped spirally, and the end plate torn off. The other half of the boiler was comparatively uninjured, the whole, though thrown from its original seating, holding together, and the furnace retaining its cylindrical shape. All the transverse seams of externally-fired, egg-ended boilers, placed immediately over the furnace, are liable to fracture unawares, and frequent opportunity has been taken in previous reports to call attention to their treacherous character. There were circumstances, however, which rendered these seams specially liable to fail in the boilers under consideration. The boilers were about nine years old, and fed with sedimentary water. Repair to the plates over the furnaces had frequently been rendered necessary on account of the leakage at the seams, though a decided improvement had been found to result on the adoption of surface blowing out by means of a scum-pipe. Also the introduction of the feed was peculiarly trying to these seams, since it was brought down from the top of the boiler by a vertical bell-mouthed pipe, terminating within six inches only, of the plates immediately over the furnace, the effect of which would be, by the intermittent introduction of the water, to induce alternate expansion and contraction and thus strain the seams. This combination of circumstances is considered quite sufficient to account for the primary fracture of one of the boilers at the transverse seams over the furnace. The fracture of these transverse seams, though very frequently attributed to shortness of water, is quite independent of it, and is constantly found to take place where the supply is ample. In these externally-fired boilers the steam is generated on a concave surface, while in internally-fired ones it is generated on a convex one, and it would appear as if the steam could not escape so readily from the concave surface as from the convex, and thus, lingering longer in its position, keeps the water from contact with the plate, and leads to its being burnt. In the internally-fired boilers, the steam generated at the sides of the furnace tube renders the stratum of water in contact with with the plate lighter than the surrounding mass, and thus an ascending current is set up which passes over its surface. This removes the globules of steam as soon as they are

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formed. and substitutes a fresh film of water to be evaporated. It will be seen that this action cannot take place upon the concave surface. and it is thought that this may account for the fact, that while instances of injury to the plates of internally-fired boilers, when fully supplied with water, are quite exceptional, they are, with externally-fired boilers, of very common occurrence. Some externally-fired boilers with a hot fire have been known to bulge very shortly after setting to work, the injury being quite independent of any accumulation of sediment, while the same plate has in some cases had to be renewed again and again, its condition affording indications of having been red-hot, although known to have always been covered with water. The fact, therefore, of these boilers having failed over the furnaces, even through overheating, cannot be accepted as an evidence of their having been neglected and allowed to run short of water. A strong impression, however, existed that such had been the case with one of the boilers, since the colour of the plates had, it was stated, been quite blue immediately after the explosion, though shortly removed by exposure to weather. It should not be overlooked however, that the mere fact of explosion may give this appearance from the shock on coming to the ground after the flight, and from the blows the boiler receives on its course. These are quite sufficient to remove, at all events in places, any protecting scale from the plates, and to lay bare their original surface, the effect of which is mistaken for that of fire. The Cornish boiler, which was the most likely to have suffered from any neglect of the supply of water, had evidently not been short, since the shape of the furnace crown, with its coat of scale was unaffected. There still remains to be explained the fact of the whole series of five boilers having exploded simultaneously. The percussive force of water, as an important element in producing the destructive effects in steam boiler explosions, has lately excited considerable attention, and is a subject of much interest. The view is as follows:—The temperature of water in a steam-boiler working at 50 pounds pressure, is 300°, which is 88° above the boiling point at atmospheric pressure. On the occurrence of a rent above the water-line, or the rending off of a steam dome, the blowing-off of the manhole cover, or the fracture of a steam-pipe, &c., the steam above the surface of the water would escape and remove the pressure from it. The 88° of free heat, with which the whole body of water is charged, over and above that necessary for maintaining it at the boiling point at atmospheric pressure, would instantly flash a considerable portion of it into steam, whiles the globules, not being generated at the surface merely, but throughout the whole mass, would blow up the water with considerable force, converting it into a projective, having a velocity equal to that due to the pressure. This would give it a destructive force far greater than that of the simple statical pressure of the steam; just as in the injector, the stream of water acquires a force of penetration, that renders it superior to the pressure of the steam that imparted it, and which enables it to enter a boiler working at a higher pressure, than the one supplying the injector. It is thought, by its advocates, that on this principle it is possible that an explosion might happen, without either the existence of any previous weakness of the boiler, the occurrence of any primary rent, or excessive pressure, but simply from the sudden removal of the steam from the surface of the water, when it would be violently projected, as just explained, against the upper part of the shell. It has been proposed to submit this to the test of experiment, and to accomplish the instantaneous clearance of the steam space, either by condensation, effected by the introduction of a jet of cold water, or by the opening of a large valve. Such an investigation would certainly be most interesting and useful, while the result would be highly prized by the engineering world. Of the fact of the sudden liberation of the steam throwing up the water there can be no question, since that is already a matter of experience; whether, however, the entire steam space can be so instantaneously cleared, as to allow a sufficient velocity of the water being attained, —on the accomplishment of which the force of impact depends,—appears to me a matter of question, and I cannot but think that steam would be generated with sufficient rapidity upon the surface of the water, to retard the velocity of the mass, as well to form a cushion which would soften the blow against the shell of boiler. This is a nice point, and must await the issue of the experiment for determination. I have for some time since, in examining exploded boilers, carefully searched for indications of this action, and it appeared at first that there were manifestations of it in the explosion under consideration. For instance, the feed water had been introduced, as previously stated, at the top of the boiler, the feed stop valve being bolted to the side of the steam dome, and the water carried by the feed-pipe through the steam space. The failure of this feed-pipe, would have allowed the water to play amongst the steam, and thus produce the very condensation desired in the proposed experiment just mentioned; added to which, the steam domes were torn off from the shells, as if by upward impact, and blown in a different direction to the boilers themselves. The feed water, however, proved to have been heated by the exhaust steam from the engine, and thus would have produced but tardy condensation: and even if the flight of one boiler, on the rending of the transverse seams over the furnace, had, carried away the steam-pipe or rent off the domes of the others, which is highly probable, and thus by suddenly relieving the steam pressure, set up this percussive action,—still, the force of the impact which must have been upward, can hardly be supposed to have developed the transverse rents previously described, or to have thrown one-half of the boiler to the south and the other to the north. With a full appreciation of the value of the impact theory, it is not thought that it applies in the present instance, as having produced primary rents, important as it may have been in developing secondary ones. The cause of the simultaneous explosion is thought to have been as follows;—A single externally-fired egg-ended boiler say No. 3, rent at one of the transverse seams over the furnace in the first instance. The escape of steam and water from the bottom of the boiler then lifted the remaining ones, and threw them up in the air several feet high, blowing down at the same time the brickwork seating, so that the boilers, on coming again to the ground, fell upon aloose irregular bed, and all became so strained that each rent and exploded in turn. That the percussive action of the steam was sufficient to have done this, as illustrated by the fact, that one of the cast-iron rolls from the mill, was lifted by it at the time of the explosion to a height of several feet. Explosions Nos. 7 and 9 were very similar in character one to the other. Neither of the exploded boilers having been personally examined, only the following scanty particulars have been obtained:—Explosion No. 7, occurred at a colliery to a cylindrical externally-fired boiler, 36ft. long and 5ft. in diameter. This boiler formed one of a series of five, being the second from the engine-house. It was sent by the explosion into four pieces, while the escape of the steam and water blew up the boiler seated next to it, which was the centre one of the series, flattening it on one side; reversing it end for end in position, and rolling it over the other boilers, finally depositing it on the ground beyond. It will be seen that the treatment of this boiler, on the rupture of the one alongside of it, corroborates the view given with regard to the cause of the simultaneous explosion of the five boilers referred to above, and it is hoped that fuller particulars may be obtained. No. 9 Explosion occurred at an ironworks, to a cylindrical externally-fired boiler, about 32ft. long and 5ft. in diameter, which was the outer boiler of a series of five. It will be observed that the seven boilers which have exploded during the month, have all been of the egg-ended externally-fired class, with the exception of the Cornish one, which suffered only, through the explosion of the others; and it is trusted that the fact of the constantly recurring failure of these externally-fired boilers will at length dispel the false estimate, so generally entertained, of their safety. The proprietor of the iron works at which No. 8 explosion occurred, at once adopted the wisest course, and resolved upon having no more of the externally-fired class upon his works, but laying down 'Lancashire' boilers in their place; experience having shown him, that the plates over a furnace of an internally-fired boiler, may fail without moving it off its seat, or causing any loss of life; while with an egg-ended boiler, its entire rupture and the flight of the parts, as in No. 7 explosion, is the result."

WATER SUPPLY.

Wallasey Water Works, Cheshire.—The well for the supply of this district with water has been finished, and is a complete success. The site of the well is some 20ft. above high water level of the sea, and now that the well has been completed, the fresh water rises to some 16ft. above the level of the sea. The quicksand and rock have been reached at a depth of 94ft. from the surface, so that there is a pressure of water from beneath the marl covering nearly equal to a head of 80ft.. or approaching 40lb. pressure on the square inch. When the first well had been formed through the marl, 80ft. thick, to the quicksand, the rush of water was so powerful that a solution of silt and sand alone could be pumped. The second well has been sunk by using 7ft. cast-iron cylinders. The cylinders have been sunk down to the rock, with the water in the well, without pumping. An inner cylinder, with a strong cast-iron bottom, having a socket of 2ft. diameter, was lowered to the bottom, and the joint made good by a diver working under 80ft. head of water. Boring tools were then worked through the 2ft. socket hole, and a lining, or guide-tube, driven tight into the true rock 10ft. deep, so as to shut out the solution of silt and sand. The boring into the true rock has been continued to a depth of 150ft. from the bottom of the cast-iron cylinders, or 250ft. from the surface. The water now rises up the bore-pipe soft, pure, and sparkling, of 5½ deg. of hardness only, and may be pumped at a rate of 500,000 gallons per day. The boring tools have opened up a natural fissure in a rock of unknown capacity and depth.

GAS SUPPLY.

The Ipswich Gas Company have reduced their price from 4*s.* 6*d.* to 4*s.* per 1000 cubic feet.

The Burslem and Tunstall Gas Company have agreed to their usual dividends of 10 and 7 per cent. old and new shares, free of income tax.

CANALS.

The Suez Canal.—The Turkish Minister of Foreign Affairs has addressed a despatch to the Ambassadors at Paris and London of the Turkish Government, on the subject of the Suez Canal. The despatch relates that when the Sublime Porte first considered the question, he reserved the right to make conditions as to certain parts of the contract, and declared his desire to see a preliminary understanding established between the two maritime powers as to the guarantees which the opening of such a channel demanded. No such understanding had been come to; and in reply to a request from the Viceroy of Egypt as to how he is to regularise his position in reference to the matter, the Sultan has felt it his duty to inform him of the conditions to which the authorisation of the Sublime Porte has always been subordinate. The Porte has no intention of frustrating the work, but requires a guarantee of the neutrality of the canal, and the protection of his interests There are two facts which have attracted attention from the beginning, first, the employment of forced labour—60,000 being permanently abstracted from their homes, a practice which the Porte cannot sanction; and, secondly, the cession of territory adjoining the canals, wherever they may be carried, which might, if the company choose, give them the towns of Suez, Tenisiah, and Port Said, and lead to the establishment, on important points, of colonies almost independent of the empire. This clause of the contract will never receive the sanction of the Porte, whose consent must be indissolubly dependent on the solution of the three following questions, namely, the neutrality of the canal, the abolition of forced labour, and the abandonment by the company of the clause concerning the fresh-water canals and the cession of the adjoining territory. The despatch proceeds to say that the company cannot complain, as a clause in the contract itself makes the approval of the Porte indispensable, and M. de Lesseps, in stipulating subsequently for farther privileges, promised to obtain that consent within eighteen months, but had never done so. Although, then, the company, having commenced the works at their own risk and peril, could not complain of the works being stopped without compensation, yet, on account of the private interests involved, the Porte is willing to take the necessary measures for returning the money the company have spent, in the event of their not wishing to proceed without advantages which cannot be granted. The company would, of course, surrender the property and the works in return for the repayment, and in that event the Porte, in concert with the Viceroy, would adopt such measures as might be most appropriate for realising the execution of the work.

The East India Navigation and Canal Company.—We learn from the company's last report that the system of works suggested and now under consideration is divisible into several projects or sections, each in itself representing a work, or series of works, capable of being executed separately from the others, and having distinct sources of revenue, though capable of receiving considerable additional value by becoming a portion of the entire system, and may be described as consisting of:—First—A high level canal for irrigation and navigation from the city of Cuttack to the Port of Calcutta, passing close to the principal towns on its route, including Balasore and Midnapoor. Second—A series of works for supplying the Deltas of the Mahanuddy, the Brahmany, the Byturnee, and the Soobanreeka, and the adjoining districts of Hidjellee, Midnapoor, Burdwan, &c., with irrigation and means of water transport. Third—A main navigable tidal canal from Balasore in the Bay of Bengal, to the river Hoogley near Calcutta, accommodating the chief places on its line, such as Tumlook, &c.; and Fourth—The improvement and opening up of the Mahanuddy River, probably by means principally of a canal, in length about 135 miles, for navigation and irrigation, commencing at Puddunpore and terminating at Dholapore, both on its left bank, between which places the navigation of the river itself is dangerous, and the obstructions difficult of removal.

The Madras Irrigation and Canal Company.—We learn from the report presented at the eighth ordinary general meeting of this company, that the following is the present state of the works and the progress made:—It appears that the Anicut at Soonkasala, and the first 17½ miles of the Main Canal are by this time finished.—the Aqueduct over the Hindry, a structure of solid stone, somewhat larger than and double the width of London Bridge, has been so far executed as to allow the passage of a body of water sufficient to irrigate a considerable extent of land below;—the five miles of Canal which immediately follow upon the Aqueduct have been completed, and along those five miles there exists some land available for irrigation;—in the next 21 miles of the Main Canal some heavy rock cutting and embanking have yet to be executed—the 12 following miles, viz., from the 43rd to the 54th mile, of the Main Canal is now complete, or nearly so;—from thence to the commencement of the Mittaconda Cutting in the 72nd mile, the work has, with the exception of some intervals of rocky excavation and heavy embankment, been executed:—which, with the Mittaconda Cutting itself, will be finished by the end of the year when the bridges, and other masonry works, such as Calingulahs and sluices, will also be completed;—from the 72nd to the 103rd mile excavation is well in hand, and there are no difficulties to be overcome;—from the 103rd to the 148th mile, the plans and estimates have been for some time past awaiting Government approval, on the obtaining of which construction will immediately commence;—the plans and estimates of the Main Line from the 148th to the 240th mile at Somaishwarum, in Nellore, are in course of completion, and about to be sent in to the Government;—the execution of the Somaishwarum Anicut has commenced, and that,—in all probability by this time the whole of the remaining works in Nellore are under construction.

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DOCKS, HARBOURS, BRIDGES, &c.

PORT ERIN HARBOUR.—The Board of Trade have laid before the House of Commons a Bill for improving the Harbour of Port Erin, in the Isle of Man, that it may be more serviceable as a shelter for vessels, especially those employed in the herring fishery. So soon as a pier has been so far completed as to form a shelter for a distance of 300ft. from the shore at low water certain dues are to be levied on vessels using the harbour; and the Harbour Commissioners of the Isle of Man are empowered to borrow money on the security of these dues for making the improvements. The dues are to be lowered when the payment of the expenses of maintaining the harbour permit.

THE LONDON, CHATHAM, AND DOVER RAILWAY BRIDGE.—The foundation-stone of this bridge was laid on the 2nd ult. This new railway bridge will run across the Thames only a few yards from the intended new Blackfriars Bridge. The railway bridge will have five spans, the centre one being 188ft., the second and fourth 177ft. 3in., and the first and fifth 163ft. span. The abutments will be of brickwork cased with Portland stone, and the foundations taken down to the city clay, at a depth of 27ft. below Trinity high water. The abutments will be built in coffer-dams of the ordinary construction, but the largest ever executed in this country. The foundations of the piers will be laid at a depth of 55ft. below Trinity high-water; and, in order to get to this depth without the expense and inconvenience of coffer-dams, large wrought-iron caissons, 18ft. in diameter, will be sunk into the bed of the river till the required level is reached, when the brick-work will be commenced inside and carried up two feet below low-water line. At this point the masonry of the piers commences, and will be laid within a temporary caisson to five feet above Trinity high-water. From this height to the level of the underside of the girders the piers will consist of clusters of cast-iron columns, of which one will be under each girder. The girders, on the lattice principle, will rest on the tops of the columns, and the headway afforded for navigation will be 30ft. 3in. above Trinity high water.

THE RIVER TYNE IMPROVEMENT COMMISSIONERS are carrying out their gigantic system of dredging with great spirit and energy. Last year they were supplied by Messrs. Thomas, Wingate, and Co., of Whitelnch, on the Clyde, with one of the largest deepening machines which had been then built, and it has lifted an immense quantity of dredge in Shields Harbour, at half the former cost. The same firm are constructing two of the largest and most powerful of the deepening machines in the world, which will also be shortly be launched for the Tyne. They will each be 1200 tons register, and each of the buckets employed in dredging by these machines will weigh 25 cwt. The cost of each vessel will be close upon £30,000. Nine screw hopper barges are also about to be built by Messrs. Wingate and Co., for the Tyne Commissioners. They will be 400 tons each, and will convey the dredgings of that river out to sea. A vessel of that character is already upon the Tyne, and as an experiment it has been very successful.

HARBOURS OF REFUGE.—The annual return states that at Dover the extent of the foundations of the Admiralty pier, or west arm of the harbour, is now 1675ft., and the length of the quay level 1539ft. The sum of £549,000 has already been voted for these works, and £60,000 will be required to be voted now, leaving £41,000 of the estimate to be voted next year; the work should be completed in November, 1864. At Alderney the outer ends of the sea and harbour walls of the western breakwater are now 1418 yards short of the limit ordered; the base of the breakwater extends to 1636 yards from the shore; 12,000 tons of stone have been deposited in the base below water. The sum of £1,027,000 has been voted for these works, and a vote of £80,000 will be required this session; the estimate was £1,300,000. At Portland the net expenditure has reached £954,260. The total quantity of rough stone deposited in this breakwater from the commencement is no less than 5,170,670 tons. The divers have now completed the levelling of one-half of the area, under the foundation courses of the masonry for the north head and fort, and have set about one-third of the bottom course.

MINES, METALLURGY, &c.

THE VIEILLE MONTAGNE.—The famous Vieille Montagne Company, known in connection with zinc metallurgy, has made public its accounts for 1863. The profits realised during the year, which was a comparatively unfavourable one, amounted to the large aggregate of £149,600, and the dividend was made at the same rate as in 1861. The price of zinc continues exceedingly low, but this very cheapness has had the effect of causing the metal to be applied to a variety of new purposes.

STERRO-METAL.—Bronze is a term applied to compounds of tin and copper; while compounds of zinc and copper are called brass. These metals in varying proportions forms the most common alloys; still there are many others, and the numbers of such is always on the increase. As various metals may be mixed in different proportions, and as a slight variation in the quantity of any one component produces a new alloy of a different character, the number and quality of alloys may be extended indefinitely. The new alloy, called "sterro metal," is composed of pure American copper, 57·63 parts by weight; spelter (block zinc), 40·22 parts; iron, 1·86; tin, 0·15. It has a brass-yellow colour, a close grain, and susceptible of a fine polish. This alloy is stated to possess great strength, a square inch of it, after being forged while red hot, sustained a strain of 28 tons before it broke. It can be drawn cold and forged like iron. The tensile strength of common gun-metal is only 17 tons per square inch, which is but little more than half the strength of sterro-metal.

PRODUCTION OF GOLD AND SILVER IN THE UNITED STATES.—An interesting lecture was delivered before the Geographical and Statistical Society of New York, by Mr. J. Smith Homans, on the production of gold and silver throughout the world, but particularly in the United States; some valuable information was imparted. He stated that though the amount of gold already obtained from the Pacific States was immense, the mineral resources in that region were, in the opinion of scientific explorers, as yet comparatively undeveloped. The gold region extends through 17° of latitude, and comprises an area of 17,000,000 square miles. The yield of the year of exportion, ending last July, was more than 100,000,000 dollars. So marvellous a development of mineral resources must eventually create a vast empire, with a commerce far surpassing anything yet known in the history of the world. The great influence which the United States have exercised upon mercantile affairs since the gold discoveries were fully set forth, and the indebtedness of Europe to this country on account of gold supplies were illustrated by the following statement:—

Export of gold from the United States for the years

1848	15,841,616 dols.	1856	45,745,485 dols.
1849	5,404,648 ,,	1857	69,136,922 ,,
1850	7,522,994 ,,	1858	52,633,147 ,,
1851	29,472,752 ,,	1859	63,887,411 ,,
1852	42,674,135 ,,	1860	66,546,239 ,,
1853	27,486,875 ,,	1861	29,791,084 ,,
1854	41,436,456 ,,	1862	36,886,956 ,,
1855	56,247,343 ,,		
Total fifteen years			590,714,059 ,,
Deduct foreign imports			157,036,698 ,,
Excess of exports			433,677,361 ,,

APPLIED CHEMISTRY.

ON THE RELATION OF VITAL AND CHEMICAL FORCE TO THE POTENTIAL ENERGIES OF MATTER, BY JAMES CROLL.—The following relation between vital and chemical force which does not appear to have been specially noticed by physicists, seems to follow as an obvious deduction from the principle of the conservation of force:—The greater part of all the force available for mechanical purposes is derived from chemical combination. Chemical combination, again, depends upon the affinity of the atoms—their tendency to approach and unite. The greater this affinity, the greater is the force, or, according to the dynamical view, the velocity with which they approach. The heat produced is also proportional to the affinity of the atoms; for the amount produced is proportional to the *vis viva* of the moving atoms at the moment of union. The force manifested in chemical combination we say existed in the atoms previously in a potential state. Potential energy is transformed into actual energy by the mutual approach of the atoms under the impulse of their affinities. Potential energy can therefore only be restored to the atoms by pulling them asunder again. Chemical change consequently in every case reduces the total amount of potential energy possessed by matter and increases its actual energy. It is true that decomposition in most cases occurs along with combination, but the potential energy gained from the decomposition never can equal the amount lost by the accompanying combination. By what means, then, does matter regain its potential energy? The agency of heat alone is not sufficient, for although heat expands bodies by separating their molecules, yet it does not, except in a few cases, separate the atoms chemically united. Neither can it be done by the electric current, for the potential energy gained by electrolysis does not compensate for what is lost in generating the current. The atoms of matter seem to be indebted to the agency of vital or organic forces for the restoration of their potential energies. Chemical agency separates the atoms possessed of weaker affinity, in order that they may unite with others to which they have a stronger affinity. Vital agency, on the contrary, separates atoms which have a stronger affinity in order to unite them with others to which they have a weaker affinity. In the latter case we have a restoration of potential energy. But potential energy can only be restored at the expense of actual energy. Where, then, does the vital agent derive its supplies of actual energy? Evidently from the sun's rays. Here we have two agencies constantly at work—the chemical and the vital. The former is continually converting the potential energy of matter into actual energy by the motion of the atoms towards each other. The latter, on the contrary, is continually restoring the potential energy lost by drawing the atoms asunder. The chemical agent produces actual energy by means of the consumption of potential energy; the vital agent restores the potential energy by consuming actual energy, viz., the sun's rays.

EXPERIMENT ON THE SEPARATION OF SAL-AMMONIAC INTO HYDROCHLORIC ACID AND AMMONIA AT THE MOMENT OF VAPORISATION, BY M. L. PEBAL.—It is known that M.M. Cannizzaro and H. Kopp explain the abnormal condensation of the vapour of certain bodies, such as sal-ommoniac, hydriodate of phosphoretted hydrogen, perchloride of phosphorus, monohydrated sulphuric acid, &c., by supposing that bodies during vaporisation are in a state of dissociation, as M. H. Deville happily expresses it. If sal-ammoniac gives 8 volumes of vapour ($H_2 O_2 = 4$ vols.), it is owing, according to these authors, to the fact that the vapour of sal-ammoniac is a mixture of hydrochloric acid and ammoniacal gas. M. Kekule entertains the same idea. But there has hitherto been no direct experimental proof of this theory, though with respect to sal-ammoniac the author has furnished this proof. The method he employed is new only in its application to this present research. M. Bunsen has shown that to decide whether a gas consists of a single or compound substance there are only two experimental solutions,—namely, by absorption and diffusion. In the case in point, it would be difficult to apply the method of absorption; by experimenting by the method of diffusion the solution of the question might be determined. In fact, if sal-ammoniac vapour is really formed of a mixture of ammonia and hydrochloric acid, it is evident the least dense gas, ammonia, ought to pass by diffusion more rapidly than hydrochloric gas into a hydrogen atmosphere. Supposing such a diffusion effected, the hydrogen atmosphere, after a certain time, should contain free ammoniacal gas, while the free hydrochloric gas should appear in the atmosphere of the sal-ammoniac vapour. This theoretical assumption has been proved to be correct by the following experiment:—Place some fragments of sal-ammoniac on a plug of amianthus in a tube drawn out at one end, and fixed inside a larger one. The tubes are traversed by a current of hydrogen, while, by means of a furnace of incandescent charcoal, their temperature is raised sufficiently to volatilise the sal-ammoniac. The sal-ammoniac vapour being formed above the amianthus plug, ammoniacal gas penetrates through the plug in quantity sufficient to blue litmus-paper placed in the course of the hydrogen which sweeps through the inner tube, while the hydrogen traversing the annular space between the two tubes, the atmosphere of which is impregnated with excess of hydrochloric acid, reddens blue litmus-paper placed across its passage. It is thus made evident that the sal-ammoniac contains free hydrochloric acid and free ammonia, for these two gasses passed through the diaphragm in unequal proportions. The use of such metals as mercury and platinum has been purposely avoided, to escape the objection that might be urged by intervention of decomposing or catalytic forces.

ANALYTICAL NOTICES ON ARSENIC, BY M. H. ROSE.—Arsenic may be estimated by difference in many of its combinations with metallic oxides, by calcination of the substance with sulphur; the arsenic volatilises as sulphide, the base remaining under the form of mixed sulphide. The operation is easily effected in a hydrogen current, but is especially successful with arseniates of manganese, iron, zinc, lead, and copper. Calcination with sulphur in a porcelain crucible completely eliminates the arsenic of arseniates of nickel and cobalt; but the weight of nickel and cobalt cannot be calculated from the residual sulphide. Arseniate of silver, heated in a hydrogen current, or with sulphur, leaves silver which obstinately retains a certain quantity of arsenic. The alumina resulting from the calcination of arseniate of alumina in a hydrogen current, whether singly or with sulphur, also invariably retains arsenic. It is the same with the magnesia resulting from ammoniaco-magnesian arseniate. The above process applies, of course, to many metallic arsenides, particularly to arsenical iron, to mispickel (arsenio-sulphide of iron), to arsenical nickel, and to grey cobalt (arsenio-sulphide of cobalt), though with greater difficulty. Grey cobalt must be previously oxidised by nitric acid, and the mixture of oxides then treated by sulphur; and this must be repeated several times. In many instances the best way to expel arsenic acid from arseniates is to calcine them with hydrochlorate of ammonia. Alakaline arseniates are perfectly transformed into chlorides by a single calcination; arseniates of alkaline earths offer more resistance, and the magnesia of the arsenic always retains a certain proportion of arsenic. Many oxides of true metals are reduced to a metallic state by calcination with sal ammoniac; but the metal will contain arsenic. Bisulphate of ammonia, as shown by M. H. Finkener, can often advantageously replace the hydrochlorate. However, the fused bisulphate attacks the porcelain crucible, which must be used on account of the arsenic, and the sulphates obtained are mingled with those produced by this attack. The arsenic is generally entirely expelled. The author has ascertained this to be the case with ammonia-magnesian arseniate, with arseniates of soda, lime, and lead. Arsenides of nickel and cobalt are more easily freed from arsenic by this method than by fusion with sulphur. Some few metallic arseniates may be decomposed by boiling with a solution of a hydrated or carbonated alkali. The author in this way has been successful with arseniates of peroxide of iron and copper; arseniates of zinc and protoxide of manganese yield oxides retaining notable quantities of arsenic.

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LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, or titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of "The Artizan."

Dated April 25th, 1863.

1035 L. A. J. Bruet—Registering, indicating, and verifying the time and distance passed over by vehicles.
1036 A. Poirrier & C. Chappat—Blue and violet colouring matters.
1037 F. Walton—Fabrics for covering floors and other surfaces
1038 C. Peyer—Safety valves.
1039 I. Dimsdale—Cleaning, sorting according to size, and doubling silk.
1040 A Legras—Making lace.
1041 J. T. Stroud—Holding, drilling, turning, tapping, fitting, and shaping certain parts of steam, water, gas, and lamp fittings.
1042 W. E Newton—Thrashing machines.
1043 A. V. Newton—Breech-loading fire-arms.
1044 M. Barland—Milking cows.

Dated April 27th, 1863.

1045 S. Osborne—Unwinding crinoline steel.
1046 G. Spill, T. J. Briggs, and D. Spill—Mill straps and driving bands.
1047 H. E. Carchon & E F. Raybaud—Hats and bonnets.
1048 J. J. Robert—Spoons and forks.
1049 W. E. Gedge—Bust pipes.
1050 M. Valkenhuysen—Castor for furniture.
1051 W. Richards—Ordnance, fire-arms, and cartridges.
1052 J. Jeffreys—Surface condensers.
1053 F. Bennett — Condensing lead and other metallic fumes and vapours from furnaces.
1054 R. A. Brooman—Twisting and doubling silk.
1055 W. H. James—Indicating the locality of fire.
1056 W. Hudson & C. Catlow—Looms for weaving.
1057 A. Rollason—Dyeing and staining fabrics.
1058 H. Beare—Thrashing machines.

Dated April 28th 1863.

1059 S Ingledew—Obtaining iron from its ore.
1060 J. & W. Morris—Breaking loaf sugar.
1061 S. Crabtree—Balling motions.
1062 G. Hall & J. Wells—Explosive compound.
1063 A. Kinder—Sheet metal.
1064 W. Clark—Paper.
1065 G. W. Fuller—Submarine lantern.
1066 J. H. Johnson—Drying and cooling grain.
1067 J. H. Johnson—Preserving property in case of shipwreck.
1068 G. S. Macdonald—Card cases.
1069 T. Moore—Laying down, protecting, and controlling submarine cables.
1070 R. Butterworth—Carding cotton and other fibrous substances.
1071 G. Davies—Agitating and mixing substances
1072 G. E. Doulsthorpe—Getting coal and other minera's.
1073 H. Y. D. Scott—Cementitious substances.
1074 S. S. Marling—Scouring, washing, and cleansing woollen cloths.

Dated April 29th, 1863.

1075 J Rowley—Recovering the fibres of wool from fabrics or materials composed of wool combined cotton or other vegetable substances.
1076 E. Rowland—Weighing solid bodies and measuring fluids.
1077 W. & E. Tarr—Pianofortes.
1078 W. E. Gedge—Permanent advertisement.
1079 E. & F. A. Leigh—Cotton gins.
1080 W. Rodger—Anchors.
1081 H Worms—Elevating guns.
1082 M. Barland & E. H. C. Mouckton—Milking cows.
1083 F. Gretton—Heating the contents of mash tuns.
1084 G. Holcroft—Pyrometers.
1085 H. W. Ripley—Printing fibrous materials.
1086 M. Henry—Beton and artificial stone and pugging clay.

Dated April 30th, 1863.

1087 J. Wibberley—Winding cotton, silk, wool, or other threads on spools or reels.
1088 A. H. Remond—Retaining the aroma of coffee and cocoa.
1089 W. Clark—Hydrocyanite of ammonia and alkaline and earthly cyanides.
1090 E. Mitchell—Reaping and mowing machines.
1091 E G. Brewer—Welding and rolling metals.
1092 C. P. Stewart & J. Kershaw—Obtaining compressed air and applying the power thereof in propelling railway and other carriages.
1093 J. Appleby—Propelling ships and barges.
1094 J. H. Johnson—Rotatory engines.

Dated May 1st, 1863.

1095 J. McFarlane Gray—Rivetting, caulking, chipping, and otherwise operating upon and treating metals and other substances.
1096 E. Jones—Drainage.
1097 W. Clissold — Fulling woollen cloths and washing and cleaning woven fabrics.
1098 W. G. Craig — Feed apparatus for steam boilers.
1099 J. Bedart—Preparation of rape seed and other oil s.

Dated May 2nd, 1863.

1100 T. L. Bissell—Charging breech-loading cartridges.
1101 W. T. Smith—Washing machines.
1102 J. W. Gibson & W. Turner—Springs for railway buffers.
1103 G Burt — Punching, stamping, or forging metals.
1104 J. Purdey—Breech-loading fire-arms.
1105 S. J. Bartlett—Straining and drawing off
1106 J. B. Dubreuil—Carts, waggons, and other
1107 J. T. & T Oakley—Garden pumps.
1108 H. Myers—Appointment clock.

Dated May 4th, 1863.

1109 E R. Southby—Extraction of scents from plants and flowers.
1110 J Fortune—Fastening together lace, blond, quilling, or similar materials.
1111 J. M., E., & C. Johnson & L. Berling—Show tablets
1112 B G. Sloper—Separating metals from earthly and other matters mixed with them.
1113 G. Haseltine—Springs for railway carriages.
1114 F. Applegate—Spring balances and pressure gauges.

Dated May 5th, 1863.

1115 J. H. Johnson—Wrought iron and steel.
1116 W. Walsh—Obtaining and purifying oxalate of soda.
1117 R. G. Kent—Shades and reflectors for gas lights.
1118 R C. Cheshire—Intercepting the solid portions of the soil of water closets.
1119 W. Boothroyd—Stationary engines
1120 R. A Brooman—Fabric suitable for trimmings.
1121 F. Applegate—Stopping and starting railway trains.
1122 P. Bradshaw—Mounting mill stones for grinding grain.
1123 J. H Knott—Pumps.
1124 W. Glover—Facilitating the steering of ships and other vessels.
1125 W. G. Wilkins—Lamps.
1126 S. B. Cochran—Sewing machines.

Dated May 6th, 1863.

1127 T. Sagar & J. Wilkinson—Power looms for weaving.
1128 J. T. Ward—Carriages.
1129 W. E. Gedge—Toy.
1130 S. Hibbert, J Lawton, & J. Kay—Cleansing potatoes.
1131 S. D. MacKellen—Watches and other timekeepers.
1132 I. M. Singer—Sewing machines.
1133 G. Davies—Forging and pressing horse shoe and other nails.
1134 T. Beesley—Boxes for carrying and packing boxes.
1135 A. Starrock—Locomotive engines and tenders.
1136 C. W. Atkinson—Steam or other motive power engine.
1137 A. V. Newton—Sewing machines.

Dated May 7th, 1863.

1138 J. Park—Communicating motion to machinery for manufacturing paper pulp.
1139 J. Snider — Breech-loading fire arms and ordnance.
1140 P. Bourne—Miners' lamps.
1141 J. Walker—Mechanism applicable to looms and partly to carding engines.
1142 A. Stanley—Finishing clasps and other metallic connectors
1143 G. Bower & A. Dick—Purification of gas for illuminating purposes, and the reduction of ores and the melting of metals.
1144 T. Small—Motive power machinery.
1145 J. Bettridge—Ornamentation of papier mache and other japanned wares, wood, ivory, and other similar materials.
1146 C. A. Day, A. Lamb, & T. Summers—Marine engines.
1147 J. B. P. A. Thierry—Furnaces to render the combustion of the fuel more complete, and to prevent the emission of smoke there from.
1148 T. Holliday—Blue colouring matter.

Dated May 8th, 1863.

1149 P. J. Livsey—Compound steam engines.
1150 A. Skwarsow—Turntables.
1151 H. Schooling—Shaping lozenge paste or other plastic materials
1152 J. B. Grimshaw—Looms for weaving.
1153 C. L. Braithwaite—Feeding slivers of wool and other material to carding engines.
1154 J. H. Bailey—Mechanical movement for producing an impelled current of air for lamps.
1155 J. C. Droop—Instrument for holding nails, screws, or other fastenings.
1156 W. Clark—Coating wrought or other iron to protect it from corrosion or oxydation.
1157 E. C. Boet—Tanning hides and skins.
1158 C. F. Beleteld—Sheets, slabs, and other articles where fibrous materials are employed.
1159 G. T. Bousfield—Steam engines.

Dated May 9th, 1863.

1160 W. Thomson—Obtaining motive power.
1161 J. Rickland—Laying veneers on to surfaces and applying the glue for that purpose.
1162 S. Wilson—Hoops or bands for fastening bales.
1163 W. E. Gedge—Paper, stuff, or pulp from certain vegetable substances.
1164 J. Norie—Moulds for casting.
1165 J. Page & A. T. Wayne—Pens.
1166 J. Brierley—Dyeing knickerbocker and textile fabrics.
1167 W. Boaler—Dryer fabric for paper making.
1168 E. R Clark—Portable wine cases or bins for domestic use or export and a pic-nic chest combined.
1169 V. Legeadre—Scissors.
1170 R. A. Brooman—Lamp black.
1171 J. B. Wood—Defending ships or vessels and forts when armour plating is employed.
1172 J. Burrell — Cutting the teeth of bevelled wheels.
1173 C. H. G Williams—Colouring matters.
1174 J. Burrell—Salinometers.
1175 J. H. Johnson—Rotatory engines.
1176 J. Lee & M. Gutteridge—Agricultural implements.

Dated May 11th, 1863.

1177 B. Hargreaves—Tiles for drainage or sanatory purposes.
1178 R. Burgess—Marking, etching, or engraving cylindrical and other surfaces.
1179 G & W. Shorrock—Power looms for weaving.
1180 C. L. V. Tenac—Railway rolled wrought iron sleeper.
1181 C. L. V. Tenac—Armour plates of hammered or rolled wrought iron, the whole of the rivets being protected against the direct blows from the cannon shots.
1182 J. Parkinson—Tablets.
1183 R. A. Brooman—Coupling and disconnecting carriages on railways.
1184 J. B. Guirette—Inhaling apparatuses.
1185 J. Shanks—Cutting the edges of grass.
1186 J. E. McConnell & G. H. Bovill—Chains for cables and other purposes.

Dated May 12th, 1863.

1187 B. Lilly—Nipple protectors for fire arms.
1188 W. Mattison & G. Barker—Grass mowing and reaping machines.
1189 T. Warren—Glass and other furnaces.
1190 H. Wickens—Reaping and mowing machines.
1191 J. E. McConnell & G. H. Bovill—Treating worn out railway tyres.
1192 W. Whiteley—Looms for weaving.
1193 G. A. Huddart—Cutting slate.
1194 H. L. Emery—Saws for ginning cotton.
1195 R. A. Brooman—Spring mattresses.
1196 R. A. Brooman—Spring mattresses, sofas, chairs, and seats.
1197 R. A. Brooman — Preparing, dressing, and winding cotton, woollen, flax, silk, and other warps.

Dated May 13th, 1863.

1198 H. Rushton—Head-dresses.
1199 R. A. Brooman—Laying submarine telegraph cables.
1200 H. Wilde—Electro-magnetic telegraphs.
1201 T. Parkinson & F. Taylor—Weaving, sizing, dressing, and dyeing.
1202 F. Holthausen—Portable copying press.
1203 J. E. McConnell & G. H. Bovill—Wrought iron armour plates.
1204 W. J. Cassavetes—Stereoscopes
1205 C. L. Kensner—Hydrate of barytes and sugar
1206 B. Lambert—Rag or pulp engines.
1207 A. G. Southby—Railway car lamps, station, signal, and other fountain lamps.
1208 J. Farmer—Calendering, embossing, and other such machines.
1209 R A. Brooman—Extraction of hydro-carburets from minerals.

Dated May 14th, 1863.

1210 T. Lawrence — Drying, dressing, brushing, waxing, and finishing fabrics.
1211 J. Satchwell, W. H. Ashford, & C. Harrison—Nails or rivets for boots and shoes.
1212 A. Pilbeam—Sewing machines.
1213 J. T. King—Wicks for oil and other fluid burning lamps.
1214 J. Burrell—Cocks or valves.
1215 G. Dowler—Match boxes.
1216 L S Chichester—Weighing grain.
1217 F. K. Erlam—Lubricating compound.
1218 G. T. Bousfield—Rolling, grinding, and cutting files and rasps.
1219 I. Parker—Connecting and securing door and other knobs or handles to their spindles.

Dated May 15th, 1863.

1220 B. Shillito & Dresser—Generating heat and
1221 D. M. Fyfe—Painting the centres of military or other targets.
1222 D. M. Fyfe—Raising, removing, transporting, and refixing military or other targets.
1223 W. Clark—Repeating fire-arms.
1224 A. Macmillan—Buttons.
1225 R. T. Mallet—Piers, walls, and landing stages.
1226 J. Patterson—Grinding, crushing, cleaning, and shelling farm or vegetable produce.
1227 J Papin, C. Lintz, and L. Lavacherie—Boots and shoes.

Dated May 16th, 1863.

1228 R., W., and T. Waddington—Combs.
1229 B. Browne—Elastic material.
1230 J. Hinks—Lamps.
1231 R. Talbot—Folding rudder.
1232 F. M. Burns—Preventing the fouling of the bottoms and sides of ships.
1233 W. Clark—Rotary engines.
1234 J. T. Newton—Planishing and rolling sheet metal.
1235 J. Gibbs—Preparing and spinning flax.
1236 W. White—Looped fabrics.
1237 T. C. Stretton—Dressing lace.
1238 E. B. Wilson—Iron and other metals.
1239 J. Whitehead—Motive power machinery.

Dated May 18th, 1863.

1240 E. Christmas—Carriages.
1241 W. Watson—Bread.
1242 H. Bennett—Facilitating the puddling of iron.
1243 A. Heather & J. Redfern—Steam boilers.
1244 B. Hebblewhite—Crushing or reducing oil cake, seeds, and other substances.
1245 R. Fenner & W. H. Hight—Envelope folding machines.
1246 S. Toy—Screw rivets, nails, or pins.
1247 J. Beaumont—Condensing machines for working yarns of wool and other fibrous substances.

Dated May 19th, 1863.

1248 C. Barnard, J. Bishop, & C. & G. Barnard—Lawn mowing and rolling machines
1249 E. Rhodes—Twisting and doubling cotton, hemp, and flax.
1250 J. Edwards—Permanent way of railways.
1251 J. H. Johnson—Breech loading fire-arms.
1252 F. Fenton—Treatment of vegetable fibres for the preparation of textile materials therefrom.
1253 R. Bunting—Frames, tips, and bolsters used in cutlery.
1254 H. J. Olding—Treating flax and other fibrous plants.
1255 J. Kelly—Treatment of peat.
1256 A. Parker—Saving from destruction by fire persons and property.
1257 L. Chandor—Mechanical lamp.
1258 T. P. Salt—Trusses.
1259 L. Chandor—Lamps.
1260 W. Smith—Transferring plain or coloured prints or designs to wood or other surfaces.

Dated May 20th, 1863.

1261 H. Wren & J. Hopkinson—Self-lubricating bearings for shafts and axles.
1262 J. Colegoard—Sewing machines.
1263 W. J C. Lang—Preserving life at sea.
1264 P. Addington—Varnishes.
1265 R. R. Jackson & W. Pemberton—Looms for weaving.
1266 T. Williams & I. Naylor—Paper spools used in spinning and doubling machines.
1267 J. T. Markall—Working wood.

Dated May 21st, 1863.

1268 J. Cassell—Treatment of mineral oils and hydrocarbons.
1269 G. R. Harding—Transmitting power on railways worked by vacuum or the pressure of air.
1270 W. Walker—Looms for weaving.
1271 J. Stuart—Extracting the fibre from zostera marina and other aquatic vegetable productions.
1272 W. Munn—Signal lanterns.
1273 F. P. Warren — Attaching copper or other sheathing to iron vessels.
1274 E. T. Hughes—Breech-loading fire-arms and cartridges.
1275 N. J. Amies—Elastic webbing.
1276 A. Thornalley—Brick kilns.
1277 W. H. Capp—Rail or holder for coats and other articles.
1278 E. Soustadt—Purification of magnesium.
1279 J. Pawcett—Preparation of food for cattle, horses, and other animals.
1280 J. Goodman—Velocipedes and wheels for the same.
1281 R. A. Brooman—Breech-loading ordnance and other small arms and projectiles.

Dated May 22nd, 1863.

1282 W. Snell—Butt hinges.
1283 C. Maschwitz—Bungs for stopping bottles, jars, and other vessels.
1284 T. A. Blakely—Ordnance.
1285 J., J., & M. H. Habershon—Rolling, polishing, straightening, and tapering round rods or bars of iron, steel, and other metals.
1286 T. A. Blakely—Rifling guns and forming projectiles to correspond therewith.
1287 G. Stevens—Coke ovens, and building and heating ovens or retorts for generating coal gas connected therewith
1288 W. E. Newton—Manufacture of waterproof fabrics.
1289 W. E. Newton—Manufacture of waterproof fabrics.
1290 J. Higgins & T. S. Whitworth—Roving, spinning, and doubling cotton.
1291 A. W. Hofmann—Preparing colouring matters & for dyeing and printing.

Dated May 23rd, 1863.

1292 J. Sturgeon—Steam hammers.
1293 E. Barlow, J. Newhouse, F. Hamilton, and W. Hope—Carding engines and lap machines, and machinery for grinding card teeth.
1294 J. A. Pickering—Covers for bottles, jars, and similar vessels.
1295 W. Cormack—Distillation of mineral or vegetable oils and spirits.
1296 S. E. Rosser and J. G. Jennings—Chimneys, fire places, stoves, and flues for warming and ventilating apartments.
1297 J. S. Bickford and G. Smith—Firing explosive compounds.
1298 W. Huey—Preparation of a fluid for renewing the surface of japanned and enamelled leathers and cloths.
1299 J. Hopkins—Crossings on railways and tramways.
1300 F. Potts and J. Key—Iron tubing.
1301 R. A. Brooman—Indicating the position of trains upon railways.
1302 R. A. Brooman—Bells.
1303 R. A. Brooman—Safety garments.
1304 F. Kingsbury—Orchestras.
1305 G. Smith—Lamps for burning hydro-carbon oils.

Dated May 25th, 1863.

1306 J. Hesford—Stretching and drying cotton.
1307 W. Muir—Cutting and assorting sugar.
1308 G. Howell—Stamping and printing machine
1309 H A Bonneville—Carriages
1310 P Leprovost—Carriages and vehicles
1311 E Hunt—Posts or pillars for fences or gates
1312 G Gestgen—Binding for trimming woollen cloth garments
1313 H B Girard—Heating apparatus
1314 T Spurrier—Ornamental metal cylinders
1315 J Hillier—Frames, sashes, shutters, blinds, and ventilators for windows
1316 C Hare—Reclining and easy chairs
1317 R Harward—Bottling and drawing off liquids
1318 M J Roberts—Preparing, spinning, twisting, and doubling wool and cotton
1319 J W Burton, S G Rhodes, & E Sesnar, and W Scruton—Getting coals or other minerals
1320 W Clark—Rolling paper

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LOCOMOTIVE ENGINEERING.

FIG 1. FENTON, MURRAY & JACKSON (LEEDS)

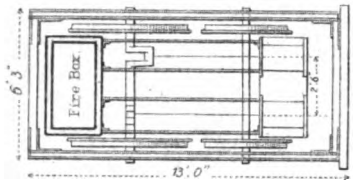


FIG 2. STEPHENSON.

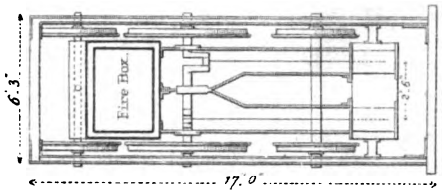


FIG 3. BURY.

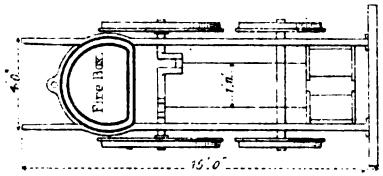


FIG 4. BURY'S IMPROVED.

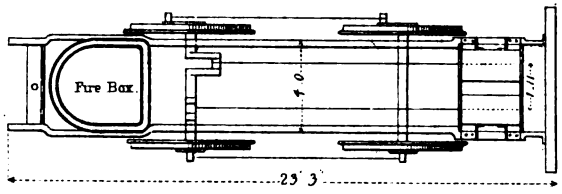


FIG 5. SHARP & FAIRBAIRN

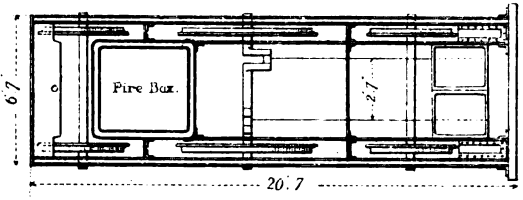


FIG 6. STEPHENSON.

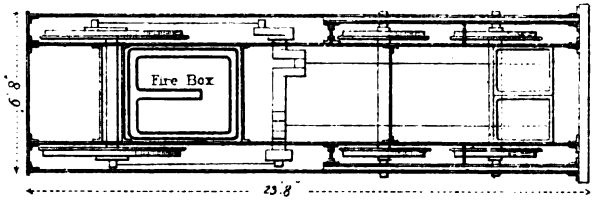


FIG 7. FAIRBAIRN'S IMPROVED.

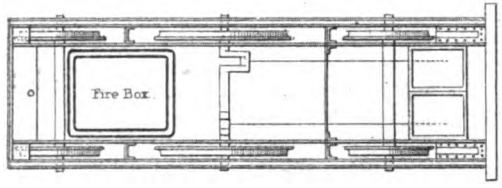


FIG 8. ALLAN.

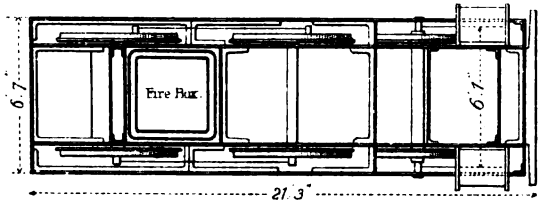


FIG 9. STURROCK & KIRTLEY.

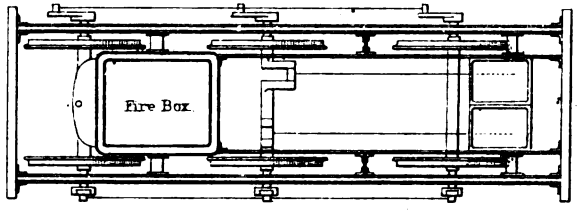


FIG 10. GOOCH.

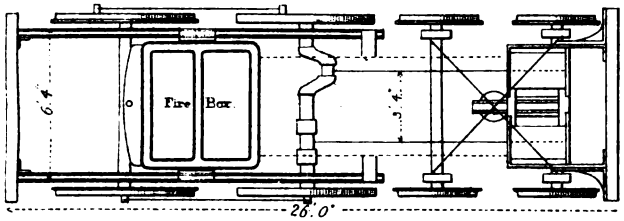


FIG 11. HAWTHORN.

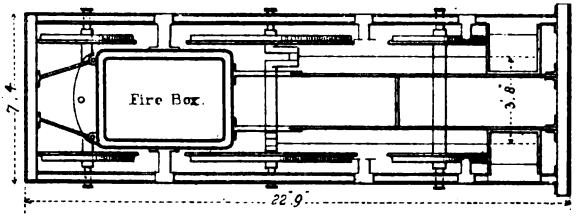


FIG 12. ADAMS.

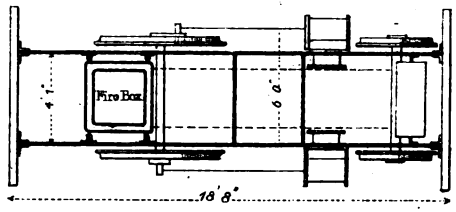


FIG 13. STEPHENSON.

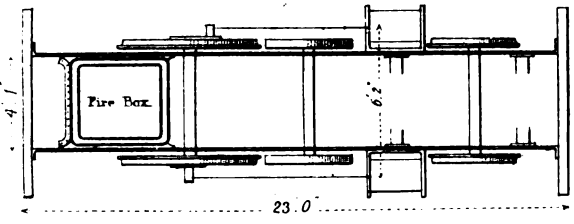


FIG 14. SINGLE FRAMED INSIDE CYLINDER ENGINE.

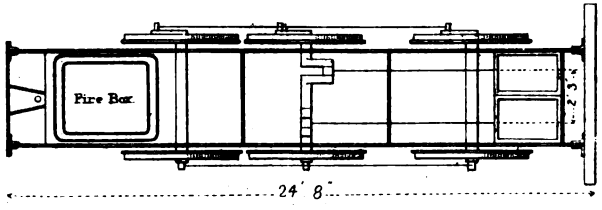
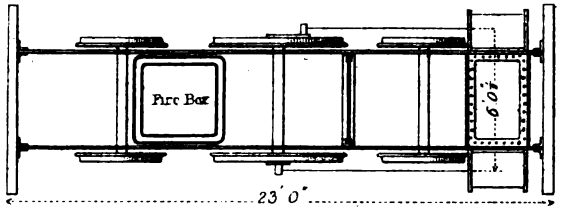


FIG 15. SINGLE FRAMED OUTSIDE CYLINDER ENGINE.



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LOCOMOTIVE ENGINEERING.

WATER SUPPLY.

FIG. 1.

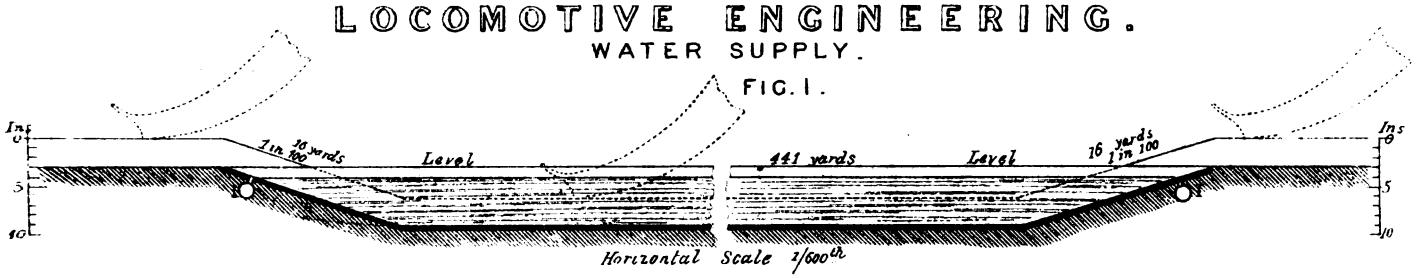


FIG. 2.

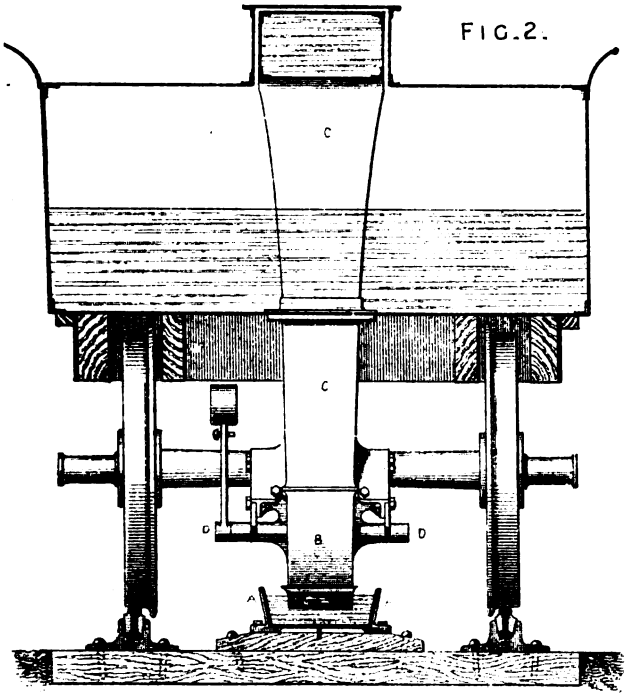
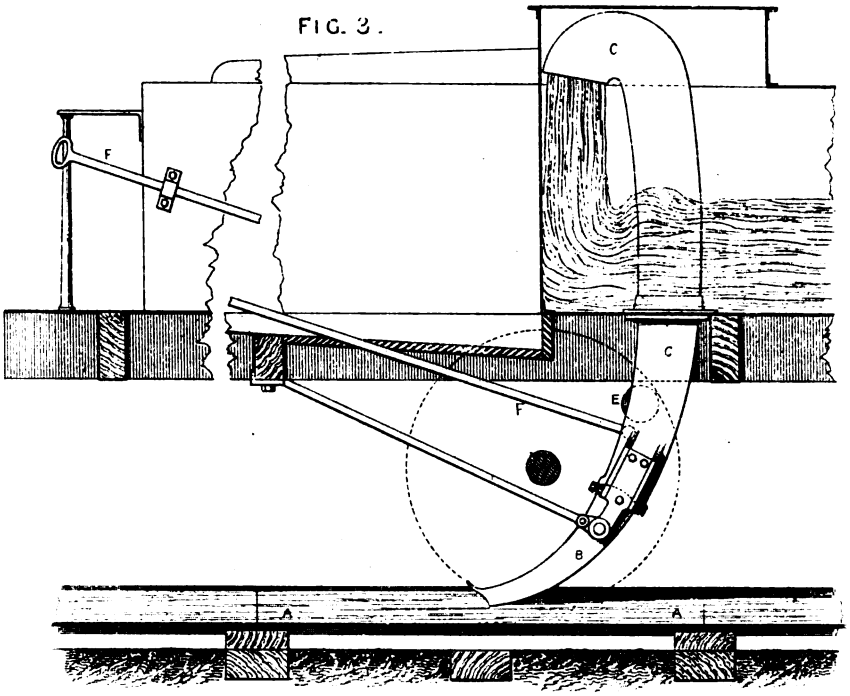


FIG. 3.



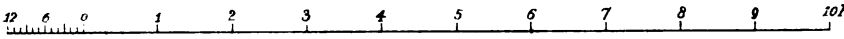


FIG. 4.

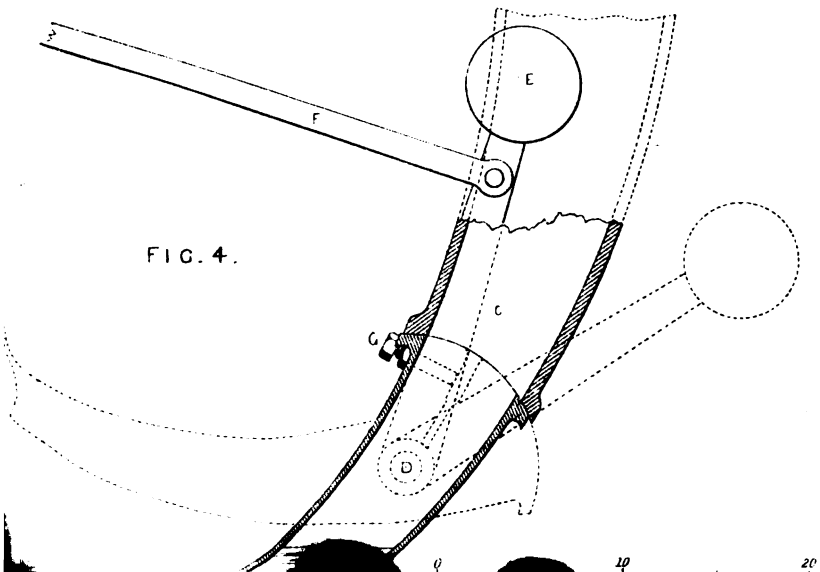
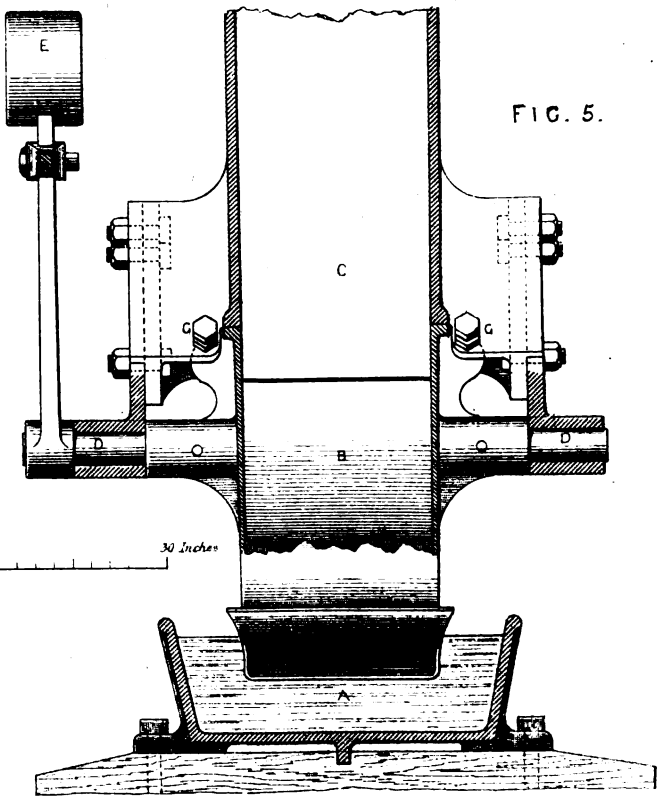


FIG. 5.



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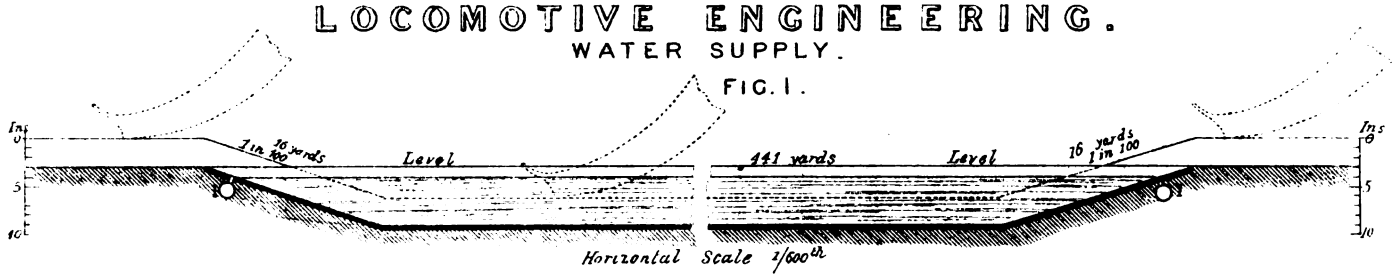
LOCOMOTIVE ENGINEERING.

WATER SUPPLY.

FIG. 1.



Horizontal Scale 1/600th

FIG. 2.

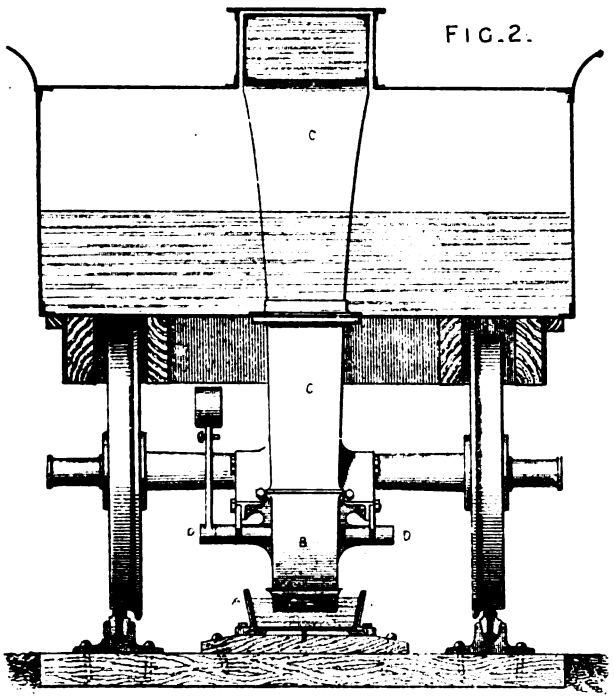
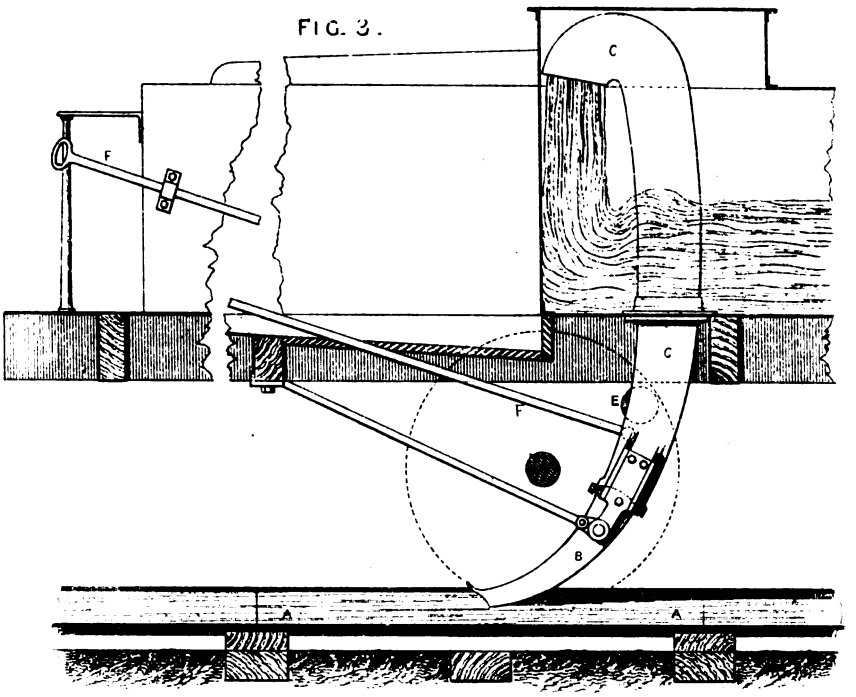


FIG. 3.



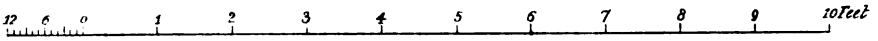


FIG. 4.

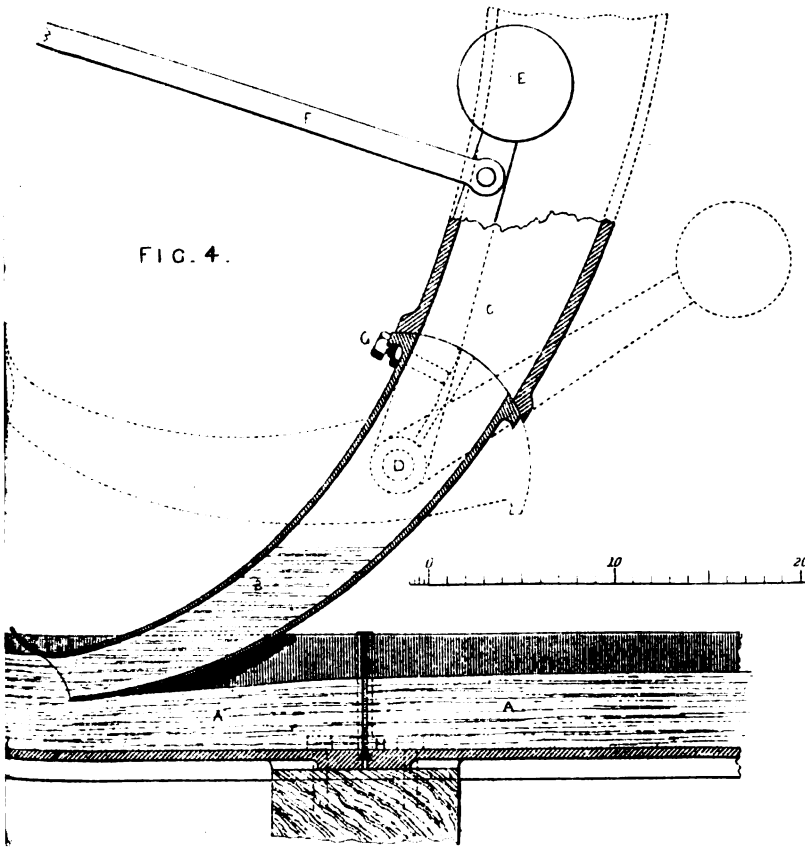
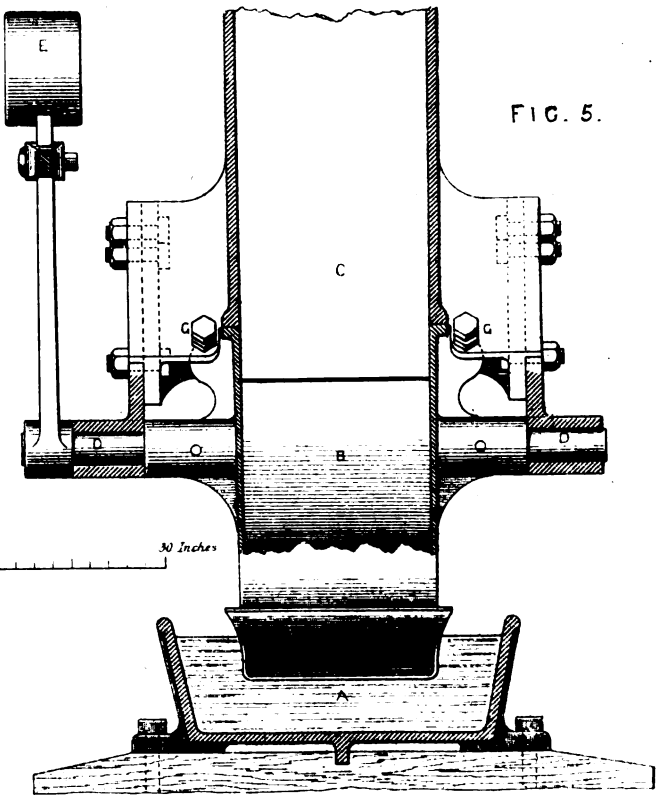


FIG. 5.



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THE ARTIZAN.

No. 7.—Vol. 1.—Third Series.

JULY 1st, 1863.

A CRITICAL AND HISTORICAL REVIEW OF LOCOMOTIVE ENGINEERING.

By J. J. Bireckel.

(*Illustrated by Plates 245 and 246.*)

(*Continued from page* 125.)

In the early attempts at propelling carriages upon railways by means of steam, it was deemed indispensable to make the rails in the shape of a toothed rack, and to provide the driving wheels with cogs fitting into this rack—an idea originated, we believe, by Trevethick, to whom the world is indebted for the first attempts at introducing the steam engine upon tramways. This method of propulsion, however, was anything but satisfactory, being necessarily attended with frequent breakages; and, as it was soon ascertained that, with an adequate load upon the driving wheels, the simple adhesion upon the rails was quite sufficient for all purposes of traction, the cog wheels and the racks were dispensed with. But to Pambour must be ascribed the merit of having defined the ratio of the adhesion to the load upon the wheels, in the same series of experiments to which we have referred in our paper on train resistances. In those experiments he ascertained that this force could amount to $\frac{1}{4}$th, and was never less than $\frac{1}{7}$th the load upon the wheels; and, though it has since been found that it may amount to even $\frac{1}{3}$th, and that it is seldom less than $\frac{1}{12}$th, yet does this in no way diminish the merit due to Pambour of having ascertained the practical limits of that force.

This ratio being known, when once the load upon the several pairs of wheels is distributed with a due regard to the stability of the engine, as has been observed in our paper on this subject, it remains for the engineer to ascertain whether the requirements of the traffic, and the physical conditions of the road for which the engine is intended, demand the coupling of either pair of wheels to the driving wheels proper. As a general rule light goods engines have the front wheels coupled, and passenger engines for heavy traffic have the trailing wheels coupled. These, though carrying less weight, in the latter instance, meet all the requirements of traction, and thus relieve the front wheels from any work but that of leading the engine, which is their legitimate duty. This class of engines, with trailing wheels coupled, which is, so to speak, the stereotyped passenger engine of the Northern States of America, is gradually being called into more frequent requisition in this country.

Finally, now it remains for us to enquire into the question of transmitting the tractile power of the engine to the train; a question which resolves itself wholly into that of the correct construction of the frame.

In the earlier locomotives the boiler itself formed the frame proper of the engine, and upon it were fixed in various ways the cylinders, while through it also was transmitted the force of traction to the train, generally by attaching the draw-bar to the back of the fire-box—nor does it appear that the introduction of the frame itself was, in the first instance, so much the result of a correct knowledge of the real wants of the case, as that of a desire to procure better means of attachments for the axle box guides, for in the engines first provided with them by Fenton, Murray, and Jackson, and also by Stephenson, they acted as carrying frames only, as is plainly seen by inspection of diagrams, Figs. 1 and 2 (Plate 245), the cylinders, in both cases, being attached to the smoke-box end of the boiler, and the draw-bar to the fire-box. This want of knowledge, however, is not to be wondered at when it is remembered that steam engineering the real wants of which could be ascertained by experience alone, was then still in its infancy, and that the whole question was of necessity in the hands of artizans, untutored in the science of theoretical mechanics which, at that time, was only accessible to those well versed in the higher branches of mathematics.

It is a singular fact that Bury, who was the first to introduce a continuous and rigid frame, running inside the wheels, from end to end of the engine, as shown by diagram, Fig. 3, did not in the first instance seize upon the opportunity thus afforded of pulling directly through the frame, but still attached the cylinders to the smoke-box, and the draw-bar to the fire-box, thus causing the force of traction to be transmitted through a circuitous route from the boiler to the frame, and from the frame again to the boiler by means of side stays, which were easily deranged, and which have been up to this day a never failing cause of leakage in the boiler, in all cases where they have been preserved.

Yet, though Mr. Bury failed to derive immediately from his contrivance all the advantages which it embodied, one great benefit was realised in the fact of having the driving wheel, the axle bearing and the crank as close to each other as possible, an arrangement which is quite indispensible to ensure the safety of the crank axle. Besides this, he soon also realised the benefits of direct connection by attaching the cylinders to the frames, and by constructing a draw-box quite independent of the boiler, by means of which also the frames were rigidly bound together at the back of the engine, as illustrated by diagram, Fig. 4. To him, therefore, must be justly ascribed the merit of having been the first to construct an engine in which the duties allotted to the boiler and to the carriage were such as to ensure efficiency with endurance, and which was the means to clearly define the very distinct functions of these two great constituent parts of the engine, viz., the frame and the boiler.

Bury's arrangement, however, while completely dispensing with the outside frame, and so far simplifying the machine, made at the same time a great inroad upon its structural beauties, since the more graceful and regular contour of the outside frame gave way to the sight of irregular wheel spokes, and of a roughly-shaped inside frame, the construction of which could not in the state of the art of forging or of rolling iron at that time, be influenced by any considerations of æsthetics. It also placed the engine upon a much narrower foundation, a circumstance which, it was not unreasonably feared, would materially affect its steadiness upon the rails. On these grounds some engineers have adhered to the outside bearings, but in order to protect the crank axle, they have provided also an inside bearing upon a frame placed inside the wheels which was stopped short at the fire-box, as in the case of Sharp's and Fairbairn's engines, illustrated by diagram, Fig. 5, where the cylinders were attached to the inside frames, and these firmly rivetted by means of vertical and horizontal cross-stays to the outside ones in order to obtain rigidity for the purposes of traction. This arrangement, however, still caused the force of traction to traverse a very circuitous route; and as the inside frame was stopped only for the purpose of gaining a couple of inches in width of fire-grate, while the means of supporting it, and of carrying the boiler at the fire-box end were thus rendered very difficult and expensive, it may with reason be said that the gain looked for was not an adequate compensation for the extra trouble incurred, coupled with the loss of the advantages of direct connection. At a later date this defect was remedied both by Stephenson and by Fairbairn, as illustrated in Fig. 6 and 7, in both which cases the wide carrying base has been preserved, while the crank axle is well protected and the line of traction is unbroken from the cylinders to the draw bar, though it should be stated that Stephenson's system of intermediate crank shaft, for reasons of economy and simplicity, has been repeated. At the present date it may be said that experience has taught, and sound practical sense does teach, that the locomotive engine should be so constructed as to have the boiler independent of all the working parts of the steam engine proper, and free from any strains arising either from the work of traction or from concussions, all of which should be borne by the frame and the other parts of the carriage alone, while to the boiler is consigned the duty of generating the steam required for the performance of the work. The boiler, in fact, should simply rest upon the carriage, upon which also should be fixed the other parts of the engine in such manner that it still might be able to perform its work, if it were possible to supply it with steam after removal of the boiler. This condition has first been realised in a satisfactory manner by Mr. Allan, of the Scottish Central Railway, in his outside cylinder engines, as illustrated by diagram Fig. 8.

It is somewhat strange that, notwithstanding the above law has been well established by the experience of more than 25 years, not only in locomotive engineering, but in steam engineering generally, it is strange that the practice of stopping the inside frame in front of the fire-box, and of pulling from the latter through the boiler, should still be persisted in by some engineers,—as for instance by Mr. Sturrock, of the Great Northern, and by Mr. Kirtley, of the Midland Railway, whose modes of connection are illustrated generally by diagram Fig. 9, where the boiler is carried on the outside frame by means of ponderous wrought iron brackets which,

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despite all improvements in the means of fastening them, never are tight. Various other systems of connection are illustrated in the sheet of diagrams, plate No. 245, with a view more especially to enable the reader to become thoroughly acquainted with the history of this portion of the subject, and as the systems already commented upon represent the chief types to be met with in modern practice, little further need be said, unless it be that Allan's system of outside cylinder engine is frequently simplified by the omission of the outside frame, at the unavoidable sacrifice of the wide carrying base. As for the engines with bogie frames, illustrated by Fig. 10, these should be but little required upon the well constructed permanent way, with easy curves, such as they are found in this country.

In America, however, where the roads are not really intended to be permanent, and where, besides, they are subject to the deteriorating influence of hard frosts, great falls of snow and sudden thaws, the bogie is found indispensible, its use is also beneficial in some mountainous districts in various parts of the continent, where sharp curves cannot be avoided.

Passing now to the consideration of constructive details of the frame, we find that Bury made them of bar iron, and in the earlier designs he generally bolted them together; later, however, he welded them together into one solid mass, as illustrated in the accompanying diagram.

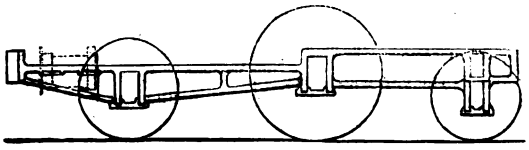

Fig. 1.

This made a very stiff and excellent piece of work, but as it is very expensive, and besides does not offer the same facilities for attachments and connections as the plate frames, is is now generally superseded by the latter. These are almost invariably made of rolled iron from 12 to 15in. deep over the axle forks and in the main body, and from 1in. to 1¼in. thick; they are usually welded in two points of their length, and though some engineers have, of late, introduced the practice of making them of one solid plate throughout, the former method is still preferred by the best makers, as well as by many locomotive superintendents of high standing, because it is less expensive, and may even be better relied upon when the plates used are of a good quality of iron, since it frequently happens that rolled plates of that thickness, and of 25ft. in length, by 2ft. 6in. deep, are not sound in the body. Outside frames are very often made of a balk of pitch pine from 10 to 12in. deep, by 3½in. thick, and lined with two thin plates varying from $\frac{7}{16}$ to ½in. in thickness. This method, however, has the disadvantage of providing a perishable frame, on account of the great liability of the timber to be destroyed by slow decomposition, a phenomenon which generally occurs where it is in contact with iron. On that ground we should prefer to see the outside frame made of a single plate, and which, when required, could be so stiffened, laterally, by means of cross stays binding it with the inside frame, as to render it fit for any duty which it may have to perform, without making it too heavy. Transversely the longitudinal frames are bound into one firm structure by means of vertical cross stays of from ¾ to ½in. thick, both in front and at the back of the engine, as well as in its mid length, this latter stay being at the same time made to carry the slide bars, and in many cases portions of the link motion; at the back the frames are bound also by the draw box, made of two plates varying from $\frac{5}{16}$ to $\frac{7}{16}$in. in thickness, of which the upper one generally answers as the fireman's platform, or foot plate, and which are united by means of vertical webs in the manner of a cellular girder. In the case of outside cylinder engines, the transverse frame connections in the immediate vicinity of the cylinders must be very strong, and should in every way offer all the rigidity of a box girder, in order to prevent the frames from being disturbed by the great side strains, occasioned by the external position of the cylinders. Convenient platforms made of $\frac{5}{16}$in. plates are also provided along both sides of the engine, to enable the driver to reach all the working parts, for the purposes of inspection and of lubrication while the engine is in progress upon the road. The connection of all these parts is usually effected by means of strong angle iron and rivets; sometimes, however, instead of using angle iron the vertical cross stays are flanged, and in that case require to be made of the best quality of Yorkshire iron. As the height of the platform measured, from the level of the rails, seldom exceeds 4ft., the driving wheels generally cut through them, and the projecting portion of the wheels is incased within a light iron box, known as the splasher, which in its design is generally more or less ornamental, according to the taste of the designing engineer, and which may certainly be made to add greatly to the artistic beauty of the engine.

In order to make our subject as complete as possible, we ought perhaps cast a rapid glance at the various minor parts of the engine with which it must be supplied in order to be in that state of completeness which enables the driver to have a thorough control over it when it is at work, and which enables the engine itself to perform all the duties which may be required of it. As the construction of these parts, however, presents no other features of interest but such as are of daily occurrence in mechanical engineering, it will be sufficient to give—more especially for the information of the uninitiated—a cursory description of each individual contrivance forming an integral part of the engine.

Beginning with the boiler, we first notice that the fire-box is provided with an ash-pan, fitted tight to its underside, and which is supplied at the front, and sometimes at the back, with air tight dampers worked by means of levers and handles from the foot-plate which enable the driver to regulate the quantity of air to be admitted for combustion, whereby he has a thorough control over the evaporative capabilities of the boiler. The ash-pan is generally formed of plates ⅜in. thick, rivetted together by means of angle iron; some attempts have been made to convert into useful effect the heat contained in the ashes, as well as the heat of radiation from the furnace, by making the ash-pan bottom of a cellular structure, and connecting it with the water spaces of the fire-box by means of pipes. The amount of heat lost, as above stated, however, has been greatly over estimated, and the result obtained has been actually *nil*, while the difficulties of construction of the machine have been thereby greatly increased. The fire-box is further provided with a glass guage, by means of which the driver can at all times ascertain the height of water in the boiler, and in order to enable him to read it at night, a lamp is placed close to the glass guage. As a measure of safety also, there are two or three guage cocks placed at different levels to enable the driver to ascertain the height of the water, should the glass guage break, or fail through obstructions to register the water level. One or two differently toned whistles are also placed within easy reach of the driver to enable him to give various signals.

Of late years it has become almost an universal practice to supply the boiler with a scum cock, by means of which the upper layers of the water may be drawn off, and along with them those impurities which float upon its surface. This has been found very beneficial in diminishing the evil of priming. A separate cock also is supplied for the purpose of warming the feed-water by means of a jet of steam directed into the tender through the feed pipes, and an approved pressure-guage is placed within close eye-sight of the driver, and has the advantage of enabling him to regulate the intensity of his fire to keep the steam at the required tension. In order to protect the driver against those inclemencies of the weather which might greatly hinder him in the performance of his arduous duties by preventing him seeing ahead, a weather board, provided with glasses, is placed close to the back of the firebox, behind which he finds shelter against head winds and rains. In countries subject to great extremes of heat and cold the driver is still better protected by a complete enclosure, both at the sides and at the front, roofed over to form a little hut, generally known as the "cab," and, though this provision slightly affects the architectural features of the engines, we do not know of any valid reason why this boon should not be granted to the driver in this country. Convenient footsteps are also placed in close proximity to the footplate, which, in the absence of the "cab," is fenced in all round and provided with proper handrails.

The engine is relieved of the gases of combustion and of the steam that has performed its work, through a chimney placed upon the smoke box, and the height of which should not exceed 15 feet, measured from the level of the rails, for the purpose of clearance when passing underneath bridges or through tunnels. Mr. Clark mentions that a length of chim-

Fig. 3.

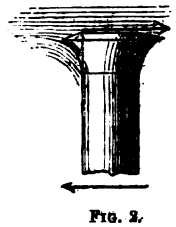

Fig. 2.

ney-proper, equal to about four times its diameter, is likely to develope the best action of the blast. That probability, however, rests upon no better foundation than Mr. Clark's own belief, and in practice no such rule is ever adopted; but the length generally is decided upon by considerations of æsthetics, subject to the limit we have above given, rather than by considerations of a proper action of the blast. With regard to its area, the same author thinks that it should be $\frac{1}{15}$th, that of the fire grate. We believe, however, that among the greater number of locomotive engineers the rule is to make its diameter either nearly or exactly equal to the diameter of the cylinders; and no doubt there is good ground to establish

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a certain relation between the areas of the cylinders and of the chimney, when it is remembered that the former is governed by the heating surface, and indirectly, therefore, by the grate area. The majority of engineers ornament the top of the chimney with a cap piece, varying in shape according to taste, but Mr. Sinclair prefers to leave it a plain finish, as being more beneficial to the action of the draught; the accompanying sketches (Figs. 2 and 3) plainly illustrate the effects of head winds upon the draught as verified by all experience on the motion of fluids and shows most conclusively that Mr. Sinclair's practice is to be preferred. With reference to the draught, Mr. Clark also lays down a very doubtful rule as to the area of the blast orifice, which he thinks may vary from $\frac{1}{10}$th to $\frac{1}{20}$th of the grate area, whereas in practice it is always ruled by the area of the cylinders, being generally made a little less than the area of the steam ports or about $\frac{1}{7}$th that of the piston.

In order to relieve the cylinders of the water which would accumulate in them through condensation of steam they are generally provided at each end in the lowest portion of their circumference with small cocks worked, by means of a system of levers and rods, from the foot plate; these are known as the mud-cocks, and in designing an engine the necessity of making provision for these secondary wants has often been more troublesome than any of the vital questions of the general problem, for the simple reason that the whole of this very complex machine has to be confined within the narrow space of about four feet.

Close to the front, the engine is provided with strong vertical bars known as the life guards, reaching down to within two inches of the rails for the purpose of clearing the latter of any obstructions which either accidentally or maliciously may have been placed thereon; and in the case of heavy falls of snow, besoms are attached to them in order to sweep the rails; this provision is of great importance in most northerly climates and in some mountainous countries on the Continent, where heavy falls of snow are of frequent occurrence. Capacious sand-boxes are placed on each side of the engine provided with pipes reaching down to within close proximity of the rails and as near to the front of the driving wheel as possible, through which the driver may strew sand upon the rails when these are slippery, to cause the wheels to bite—a want which is generally felt at starting. To the immediate front of the engine a strong beam made of oak or teak, and known as the buffer-plank, stretches across from frame to frame, to which it is securely bolted; it varies from 14in. to 16in. in depth, and from 5in. to 6in. in thickness, and in width it covers the extreme points of the carriage measured over all. To this plank are bolted two buffers in such manner as to correspond with those on the ordinary carriages upon the line, and those generally used are De Bergue's india-rubber, or Brown's spiral spring buffers; a strong drawbolt provided with shackle, chain, and hook is also fixed to it, in order to enable the engine to pull any required load whilst running backward.

Fig. 4.

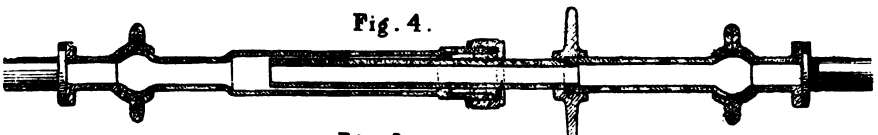
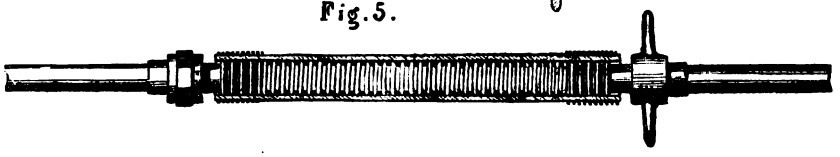


Fig. 5.



Finally to protect the boiler as much as possible against loss of heat from contact with the atmosphere, it is usually covered with a layer of felt all round the circumference of the barrel, and upon the fire-box as far down as the platforms; this layer of felt is lagged over with inch pine, and the whole covered over with thin sheet iron, No. 16 wire guage, held in its place by means of hoops or straps. In the corners of the fire-box this clothing is made complete by means of ornamental covers made of brass or of thin iron, so arranged as to hide the lagging; the steam dome is protected by means of an ornamental covering made of brass or sheet iron, and the safety valves are covered with an ornamental funnel of the same material, and sufficiently high to prevent the steam, as it escapes, from inconveniencing the driver. Those portions of the clothing which are made of brass are generally polished bright, and the parts of the engine exposed to view are covered with several coats of paint and varnish, of varying shades, according to the taste of the designing engineer.

So far we have confined our investigations to the engine alone; but as the tender is an inseparable adjunct to the former, except in those engines which, upon short lines of railways, are made to carry their own supply of water and fuel, we shall not have completed our study unless we give a short description of this faithful help-mate of the locomotive engine.

Generally speaking, the tender is a simple carriage, upon which is placed a tank, capable of carrying the requisite supply of water and fuel for a given length of journey, and in construction, this carriage is very similar to that of the engine, though, being subject only to the strain resulting from the transmission of a fair pull, and from carrying a dead weight, it may be proportionately lighter in the frame. This latter is sometimes made of four longitudinal plates of rolled iron, arranged in pairs at each side of the tender, the one outside the wheels, provided with the axle box girders and horn blocks, from 10 to 12in. deep in the body, by $\frac{3}{4}$in. thick, the other placed inside the wheels, being a plain stretcher $\frac{1}{2}$in. thick, and of the same depth as the outside one; sometimes this outside frame-proper is made of a baulk of timber from 3 to 3$\frac{1}{2}$in. thick, lined with $\frac{7}{16}$in. plates of rolled iron similar to that already described when treating of the engine frame, and with which it is usually made to match. Transversely the longitudinal frames are connected by means of vertical stays made also of rolled plates, well stiffened by means of angle irons and horizontal gusset plates; at the front, and sometimes at the back, strong draw boxes, somewhat similar to that on the engine, also answer as transverse frame connections, the whole forming a rigid structure capable of transmitting the horizontal strain without the assistance of the tank, which in reality should rest freely upon the frame. In some cases the draw-box at the back is superseded by a buffer plank, similar to that at the front of the engine, and to which, when so applied, are attached the draw hook, and the safety chains, as well as the buffers. In order to ensure the steadiness of both engine and tender upon the rails, and to protect also the feed pipe connections from undue strains, the engine and tender are kept taut by means of a strong transverse spring resting horizontally in the draw-box, against this spring two small buffers, sliding horizontally in guides fastened to the box, are made to butt, and by the elastic force of the spring are constantly pressed against the back of the engine.

Some engineers prefer to make the tender frame entirely of wood, though it is difficult to ascertain a valid reason for this preference, since the cost of a wooden frame, as generally made, is very nearly if not quite, equal to an iron one, while it does not offer the same guarantees of strength and durability as the latter. To complete our remarks on the carriage, we should state that the wheels, the axles and the axle-boxes are, in construction, exactly similar to those we have described when treating of the Engine.

A powerful break is provided, by means of which the driver is enabled to accelerate the stoppage of the train when approaching a station, or in cases of emergency. It is worked from the foot plate by a hand wheel and screw, communicating an angular motion to a shaft with short levers forged or keyed upon it, and to these are attached the tension rods, by means of which the break blocks,—which generally pivot upon a centre fixed upon the frames,—are pulled against the wheels; the break is generally so constructed as to act upon all the wheels, and sometimes it is made to grasp the wheels on both sides, to prevent undue strain upon the axles.

Tenders with a capacity of from 800 to 1100 gallons of water have two pairs of wheels only, and generally do not exceed 16ft. 6in. in length measured over all; those of greater capacity are carried upon three pairs of wheels, and may reach a length of 20ft.

The tanks are constructed in different shapes, but that most prevalent is the one which in plan assumes the shape of a horse-shoe, the water being contained in that portion which forms the horse-shoe, and the fuel being stowed in the open space between the two legs. Sometimes it is made in the shape of a plain square box, rather shallow, with its sides projecting above the top of the tank-proper, upon which the fuel is stowed; this method is adopted with a view evidently of keeping the centre of gravity low. Sometimes, also, in longitudinal section, it assumes the shape of a trapezium, the front wall of the tank sloping up backwards in an easy curve, while the side walls are carried up square, and the fuel is stowed in the space thus left free. In each case the tank is made of rolled plates, varying from $\frac{3}{16}$ to $\frac{1}{4}$in. in thickness, jointed by means of 2in. angle irons and $\frac{1}{4}$in. rivets; an ornamental coping is carried all round the top of the tank, which further adds to the fuel space.

The communication between the engine and the tank is maintained by means of continuous flexible pipes on each side of the engine, and various contrivances have been adopted to enable these junctions to adapt themselves to the shifting requirements of the engine upon the road, without interrupting the communication. The one formerly in general use, which is known as the telescope pipe, is illustrated by the accompanying woodcut (Fig. 4), and consists of two distinct portions of pipes assembled by means of ball joints, the one portion being enlarged on the greater part of its length to such an ex-

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tent as to enable it to receive and to allow freely to slide inside of it a hollow plunger equal in diameter to the feed pipe, and connected to the other ball joint by means of a screw coupling; the joint between this plunger pipe and the barrel being made good by means of a stuffing-box. This contrivance, which answers its purpose very well, requires to be made of brass, and being of difficult workmanship, is for these reasons very expensive. Soon after the discovery of the properties of vulcanized india rubber and its introduction into various useful arts, the just described contrivance was replaced by the much simpler, and equally effective one illustrated by Fig. 5, which consists of two short couplings ribbed upon their internal circumference, and connected by means of an india rubber hose, kept stiff by means of a wire coil placed inside of it.

The capacity of the tank must be determined by the nature and requirements of the traffic for which the engine is intended; according to Mr. Ramsbottom, a maximum volume of 28 gallons of water per mile, are required for a heavy mail train upon a heavy road; and at this rate of consumption, a tender having a capacity of 800 gallons would be required for a journey of 30 miles, and a tender of 2000 gallons for a journey of 70 miles without stoppage; these are the two extreme limits of tender capacity to be met with upon English lines of railway, and the space allotted for fuel is about one-fourth that for water.

Of late, however, the requirements of the Irish mail service, compelled Mr. Ramsbottom to perform the journey between Chester and Holyhead or a distance of 84¾ miles in 2 hours and 5 minutes, and necessitated the increase of the size of tender tanks from 2000 to 2400 gallons, or else required the taking of water at some convenient point upon the road, either by stopping or by picking it up whilst running. The first method of solving the problem involved an objectionable increase of weight in the tender, resulting in a loss of locomotive power equal to that required by an additional carriage to the train, while a stoppage entailed a loss of time which could not well be spared upon that heavy road in bad weather. Mr. Ramsbottom, therefore, conceived the idea of picking up the water whilst running, by dipping a pipe into a trough laid longitudinally between the rails, the dip pipe being curved forward at its lower end in the direction of motion; by this contrivance it was expected that the water would rise in the pipe to a height nearly equal to the head of of water, which would produce a velocity of outflow equal to the speed of the train, and he soon reduced his idea into a practical shape by means of the apparatus illustrated in Figs. 1 to 5 (plate 246), which is so simple that it scarcely needs to be explained. It consists of a cast-iron trough 18in. wide by 6in. deep, laid upon the sleepers between the rails, in such a manner that when it is full, the level of the water shall be 2in. above the level of the rails, as shown in Figs. 1 and 2; and further, it consists of a scoop or dip-pipe for raising the water, made of brass and having an orifice 10in. wide by 2in. high; this scoop is carried upon a transverse centre, and when not in use it is tilted up by a balance weight, as shown in Figs. 3 and 4, and in order to dip it into the water, it is depressed by means of a handle worked from the foot plate which requires to be held by the driver as long as the scoop must be kept down; when it is lowered, its bottom edge is level exactly with the rails, consequently dipping 2in. into the water, and the limit of depression is fixed by means of two set screws which answer as a stop, and which afford also the means of adjustment when the axle-box brasses and the wheel tyres are worn down.

In order to diminish the velocity of discharge of the water into the tender, the delivery pipe is enlarged gradually from the bottom to the top in such manner that the area at the top be 10 times that at the bottom, and consequently the velocity of discharge is one-tenth only that of the train; if, therefore, the water be picked up at a speed of 50 miles per hour, it will be discharged into the tender at a speed of 5 miles per hour or 7ft. per second, which is that due to a head of about 1ft.

One of the most important points, and by no means the least difficult in the practical application of this apparatus, was, at first, to provide a sure and ready means of lowering the scoop into the trough; this problem, however, has been solved in a most satisfactory manner, rendering that part of the operation of taking water quite independent of the thoughtfulness or skill of the driver, viz., by simply lowering the level of the rails with an easy slope in the whole length of the trough, as shown in Fig. 5.

The trough laid down on the Holyhead line is about a quarter of a mile long, cast in lengths of about 6ft., and made water tight, and flexible at the joints by the interposition of a round strip of india rubber. The maximum quantity of water which may be raised, is equal to the area of the scoop multiplied by the length of the trough, and in the case instanced amounts to 1150 gallons; the results obtained in practice are as follows:—

at 15 miles	0	gallons.
at 22 do.	1060	do.
at 33 do.	1080	do.
at 41 do.	1150	do.
at 50 do.	1070	do.

showing that the apparatus may safely be relied upon at any speed upwards of 20 miles.

This is unquestionably one of the most interesting applications of a principle in hydraulics known to us since the days of Toricelli, and which will probably become very general in the railway practice of thinly-populated countries abounding with clear water courses; it recommends itself at once also on the score of economy since it saves both the working expense of raising the water into an elevated tank, and the first cost of the pumping machinery. Independently of this it is deserving of special notice, on account of its ingenuity.

(To be continued.)

SUBMARINE TELEGRAPHY.

Captain Selwyn, R.N. proposes to employ an apparatus for paying out electric telegraph cables, which he has described as follows:—

One, two, or more cylinders, if preferred, of plate iron, ¼in. thick, are constructed to carry such portion or portions of the cable to be laid as may be thought desirable; but as it is most convenient to make the necessary calculations on some known basis, the Atlantic cable is first taken as an illustration.

That cable weighs one ton per mile in air. In water 14 cwt. Its diameter is ⅞in. Its cost about £100 per mile. The distance laid is 2022 miles, and the distance between Valentia, Ireland, and Trinity Bay, Newfoundland, is 1650 nautical miles, 3000 miles will be taken as necessary in these calculations.

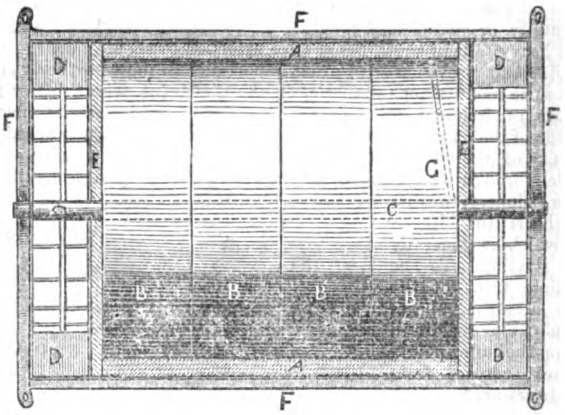

Fig. 1.

The size of cylinder, with paddle wheels attached, which will carry 1500 tons, or half the cable, at less than half immersion,—say about 20ft. draught,—is 60ft. long and 50ft. diameter, this gives a tonnage of 3366. The cylinder being formed of ¼in. iron plate throughout with double ends, 3 partitions, wheels, frame and stays, rivets, angle irons, &c., the rough estimate of weight is 300 tons, which at £20 per ton (to allow for manufacturer's profit), will be £6000 total cost.

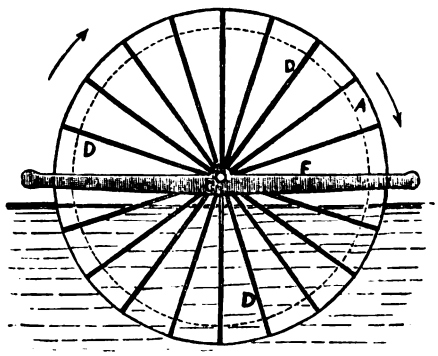

Fig. 2.

But the present light cables may be carried at considerably less expense, if, indeed, one or two thousand pounds be considered an object in carrying a cable, whose cost must be reckoned by hundreds of thousands, and in which a difference of 6d. per lb. in the expense of manufacturing the gutta-percha would more than cover the whole of the cost of laying by these means, that difference (as 400lb. of gutta-percha are used in each mile, of 3000 miles) being equal to £30,000.

In the accompanying diagrams, Fig. 1 represents a horizontal sectional plan of the cylinder, &c., A being the layers of cable coiled round the

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cylinder B, which is formed in four compartments; C is the hollow axle; D D the paddles at each end of the cylinder; E E the ends of the cylinder; F is the external frame by means of which the apparatus is towed; G is the tube through which the inner end of the cable is led. Figure 2 is an end view of the apparatus.

The draught of water of such a cylinder will be about 6ft. when light, and it would in that state take a weight of 5 tons at 10ft. from the centre, to deflect it one quarter of a degree from the horizontal. With reference to the objection advanced on acconnt of the resistance to towing, which will be considerable when not laying cable, Capt. Selwyn argues that the drawback on this account is not of so serious a character as might be anticipated; one steamer, it is well known, can tow another of her own size at a very small diminution of her speed.

Thus, if 800 horse-power propel a ship 10 knots, then two ships of equal size will be propelled by the same power acting in one of them, not 5 knots, but 8 nearly.*

If, during the laying, the cable should by any accident be broken, means are provided by which the cable may be caught and held, even miles astern of the ship, until she can go back, and, picking it up, make a splice, and proceed anew. If the cylinder be cast off, or the tow ropes broken, so soon as any strain is felt upon the cable by the drift to leeward of the cylinder, the result will be, that the cylinder will turn round and "ride to" the cable, veering slowly in answer to the strain, but resisting any rapid pulling off of cable by the beating of the paddles on the water,

Arrangements are made for reefing or expanding the paddles during revolution, so as to regulate the amount of slack, or tightness, of cable as desired. Also for testing through the cable electrically during the coiling on, or laying, by passing the end of the cable, which is first coiled on, out through one of the axles; there it is allowed to turn freely, in contact with a spring, or dipping into a cup of mercury, as preferred. The details of the calculations of weight and cost of cylinder for carrying a submarine telegraphic cable, such as the Atlantic, are thus stated by Capt. Selwyn:—

	Ton.	cwt.	qr.
Weight of cable in air per mile	1	0	0
„ in water	0	14	0
Diameter	⅝ inch.		
Length	3000 miles.		

The cable to be carried thus. Two cylinders are to be built of ½in. iron, each 60ft. long by 50ft. diameter, with double ends 2ft. apart, and paddle wheels attached, the ends to have a diameter of 56ft., and the whole to be surrounded by a frame, in which the axles revolve. The tonnage of each of these will be as follows:—

Area of 50ft. = 196,350 × 60 length = 11781000 ÷ 35 (cubic ft. in one ton) = 3366 tons burden.

Ends:—area of 56ft. = 176 × 2ft. wide = 352 × 2in. = 704 ÷ 35 = 20 tons.

Thus we get a total supporting power of 3,386 tons. The weight of cable to be carried, at, say, one-third immersion, will be thus ⅓ of 1500 = 500, therefore we have 1000 tons plus (500 × 14 cwt.) 350 tons, or 1350 tons weight of cable. The gross tonnage 3386 − 1350 cwt. of cable = 2036; 2036 − 1350 = 685 tons less than half immersion.

Now the weight of the cylinder will be about 300 tons, this also must be taken into consideration; 686 tons — 300 tons, leaves 386 tons less than half-immersion as the datum for calculating draught of water—

60 × 50 = 3000 cubic feet ÷ 35 (number of cubic feet in one ton) = 85 tons for the first foot.

Now roughly dividing 380 by 85 gives about 4ft. 6in. as the draught corresponding to 386 tons. This means 4ft. 6in. less than half-immersion, or 20ft. 6in. as the load draught.

The calculations of weight are as follows:—

BARREL.

Length of Cylinder.		Circumference of 50ft. diameter.		No. of lbs. in 1 sq. foot.		Weight of Barrel. lbs.
60 ft.	×	157,080	= 94,248 ×	20	=	188,496

3 PARTITIONS.

Area				Weight of Partitions. lbs.
50 ft. = 196,350 × 3 = 589,050	×	20	=	117,810

* Capt. Selwyn states as an illustration of steam towing, that Capt. Ericsson's small screw vessel, of 45ft. length, 8ft. beam, and drawing 2ft. 3in. of water, towed the American ship *Toronto*, of 630 tons burthen, on the Thames, 25th May, 1837, at the rate of 4½ knots per hour against tide.

4 ENDS, 56 FEET DIAMETER.

Area.				Weight of Ends. lbs.
56 ft. = 246,301 × 4 = 985,204	×	20	=	197,040
Assumed weight of frame, wheels, stays, rivets, angle iron, cuttings, &c., &c., 80 tons, or			=	179,200
			Total...	682,546

$$\frac{682,546}{2240} = 304\frac{1}{2} \text{ tons.}$$

Total weight of cylinders and attachments 304 tons, multiplied by £20 per ton, to get probable cost, gives £6080.

Next, there is the calculation of the thickness of cable when reeled on cylinder; the total number of miles in one layer; and the number of layers on the cylinder when 1500 miles are coiled on.

Diameter of cable, five-eighths of an inch; length, 1500 miles; mean diameter of cylinder and cable, 52ft.: length of barrel, 60ft.

Then—

Circumference of 52 feet = 163·36

Number of turns of five-eighths of an inch in 60ft. 1158·4 × 163·36 = 188409·424. and

$$\frac{188409·424}{6082*} = 30·9, \text{ and}$$

$$\frac{1500}{30·9} = 48·5 \text{ layers.}$$

48·5 × 5 ÷ 8 = 2ft. 6in. thickness of 1500 miles of cable when reeled on.

The cylinder should, after launching, be brought to the nearest wharf which has the required depth of water for its flotation when loaded. Being moored off, it may either be set in motion by the tide or current, or if in dock, the paddle floats being taken off, or reefed in, it may be caused to revolve by bands from portable steam engines on the wharf, and the cable will be coiled on as cotton on a reel. Testing with the cable *in water* can be carried on during the whole of this operation, the inner end having (before beginning the coiling) been passed out through one of the axle-ends. The next thing will be to replace the paddle floats, if these have been reefed or taken off; and now with the end secured, the cylinder may be taken in tow for its destination. The paddle-wheels will cause revolution, and diminish, by so much, the retarding effects of friction.

Having arrived at the point in mid-ocean or elsewhere, from which the operation of laying is to commence, the ends of the cable, of which 1500 miles will be on each of the two cylinders, are joined up, and the towing vessels start for their respective shores.

Any speed judged desirable, or which the towing vessel is able to accomplish, may be kept up regularly and without danger. A speed of 10 knots would cause the cylinder to revolve at the rate of about six turns per minute, or the outside of the cylinder would have speed of 1013·6ft. in a minute, which, for a paddle-wheel, is not excessive, the *Great Eastern* having considerably more. Supposing each ship to have gradually reached even this speed, and that the curve of cable between them were 100 miles, it is clear that any surge caused by a wave would be felt, first by the ship, next by the cylinder tow ropes, which will have an elasticity due to the catenary curve in which they must hang, and then by the cylinder; and last of all, and but slightly, by the cable, which is at no time absolutely checked in its unwinding.

When the pull comes on the cylinder, the immediate result is to bring a greater turning force on the paddle floats, and thereby to give off more cable than the 10-knot speed required.

Further, to obviate any possible strain to the cable, there is a provision as has before been stated, for expanding, or reefing, the paddle floats while towing, so that the diameter of the wheels, which govern the revolutions, can be increased or diminished, relatively to the barrel of the cylinder, the result being, that as much, or as little, slack is laid as may be proper.

While there is great depth of water, and consequently great suspended weight of cable, the wheels will be deeply immersed, and great resistance will be opposed to any more cable being dragged off, than the percentage of slack which has been decided on. If the depth alters, the resistance immediately increases or diminishes with it, by the weight of cable hanging under being also altered, and as the cable goes off, the cylinder rises out of the water, opposes less resistance to towing, and has fewer floats immersed. As the shore is approached, the draught of water will have lessened, so that the cylinder itself may, if requisite, be towed into the harbour, instead of a second shifting into boats, which may easily be a cause of damage.

* No. of feet in one nautical mile.

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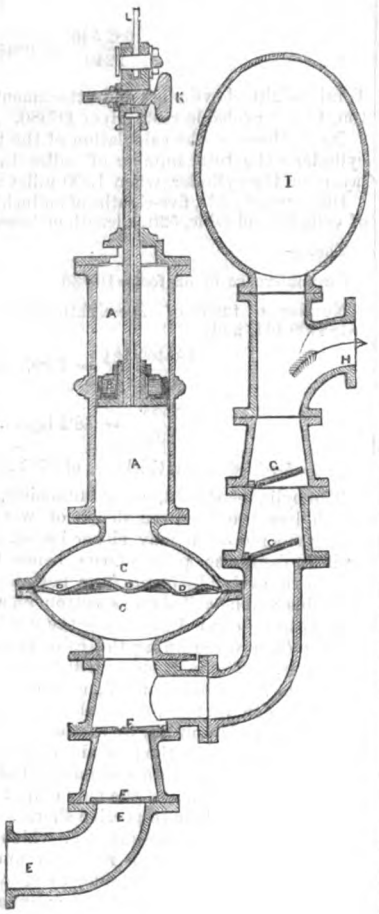
WALKER'S DIAPHRAGM MUD-FORCING PUMP.

This pump has been specially designed to obviate the objections which have hitherto existed against the employment of any contrivances in which water, highly charged with solid matter, is allowed access to the working barrel of the pump.

It will be seen from the accompanying illustration, that in the pump under notice the thick muddy water never passes above the vulcanized india rubber diaphragm D D D, which oscillates in the chamber C, with the piston or plunger B. A, being the working barrel or cylinder; E, the suction pipe; F F, suction valves; G G, delivery valves; H, delivery pipe; I, air chamber; K, tap to let out the air from, and water into the cylinder when first starting the pump; L is the connecting rod.



Double valves are provided both above and below the diaphragm, so that in case of one valve being fouled, the action of the pump may still be carried on without interruption.

This pump is now being tried at Birmingham, where the whole sewage of the town is collected in large ponds at Saltley, and where the deposit has hitherto been a source of great expense. Pumps of this description may probably be found a valuable substitution for the filth-hoists proposed for the outfall tanks of the Metropolitan Board of Works.

The employment of this pump which will effectually distribute liquids, however copiously they may be charged with solid matter, is well worth the considera- of all public bodies having to deal with large quantities of sewage.

THE ENGINEERS OF THE ROYAL NAVY.

We have on frequent occasions endeavoured to make out a case on behalf of the Engineers of the Royal Navy, and the great and urgent necessity which has so long existed for an improvement in the *status*, the pay, and treatment of this most valuable body of naval officers.

Our attention has been drawn to the printed document prepared for, and sent to the members of the Committee of the House of Commons, on the promotion and retirement of naval officers; and as we consider the subject one of national importance, we give a copy of the document *in extenso*.

"ROYAL NAVAL ENGINEERS.

"The following is a statement of the disabilities under which the Royal Naval Engineers consider they labour, and of what they deem necessary to place them on a more satisfactory footing than they at present occupy in Her Majesty's Service:—

"1st. That the pay of Naval Engineers is insufficient, and that an increase of pay n their case would be a measure not only of justice but of wise economy. Of ustice, because with their present rates of pay they are unable to maintain the position their rank in the Service demands, and also because the other officers of the civil branch, of equal rank, are better paid for services which the engineers consider are neither more responsible or arduous than their own. And of a wise economy, because by increasing the pay, the Admiralty would then be able to secure the best of the engineering talent of the country for the Royal Navy, and as the duties and responsibilities of the engineers are daily increasing in consequence of the various additions and alterations to the mechanical arrangements of ships generally, so also is the necessity for increased skill and intelligence on the part of the Engineers.

"2nd. That Naval Engineers be permitted to retire at an earlier age than at present allowed, with an addition to the rate of half-pay to which they may be entitled. Te request for retirement is submitted on the consideration, that from the peculiar and trying nature of an engineer's duties, his constitution receives injury, and as a rule it will be found he is physically incapacitated at an earlier age than 60 years, for the active discharge of the duties of a Chief Engineer at sea.

"3rd. That the accommodation for Assistant Engineers, is—as a rule—positively bad; that it would be conducive to the good of the Service if they were made Gun-room Officers; that the senior Assistant in all ships should have a cabin, and that when an Assistant Engineer is in charge, he mess in the Ward-room. The accommodation generally is so bad, that we believe it to be one great cause of disease, and were the Assistant Engineers made Gun-room Officers, we believe it would tend not only to improve those already in the service, but be the means of inducing a superior class of candidates to offer themselves for entry, as well as saving space in the ship. The peculiar duties devolving upon the Senior Assistant, make the want of a cabin more felt by him than by any of the others. Allowing the Assistant Engineer in charge of the machinery to mess in the Ward-room would be beneficial to the Service, by placing him in close communication with the other heads of departments in the ship, and materially strengthen his position in the execution of his duty.

"4th. That Assistant Engineers, after serving the prescribed period, and having passed either a provisional or other examination, receive the pay of the next higher class, that after becoming commissioned officers they be allowed a scale of half pay, and that all time served from date of entry count for full and half pay, their names also to appear in the Navy List on becoming commissioned officers. Under the present system the Assistant Engineer after serving the stipulated period, and passing his examination for a higher class, is kept waiting for his promotion, generally for a long and indefinite period, which we think ought not to be the case.

"5th. That the widows of engineers be granted ordinary pensions. They feel convinced that this measure is one of great moment to the junior branches of the class. The nature of an engineer's duties frequently impairing or destroying the health of the most robust, before they attain the position of Chief Engineer.

"6th. That a distinct rate of half-pay be granted to Inspectors of Machinery afloat, according to their rank, and that full and half-pay both of inspectors of machinery and chief engineers be allowed to increase at a proportionate rate for each year's full pay service, as the present system of requiring five years' service to be completed, for an increase of full and half pay, is productive of great hardship to those officers who from illness or inability to procure employment fall short (possibly by only a few months) of the required time, and thereby lose the advantage of their service during the remainder of the interval.

"7th. The Engineers of the Royal Navy, viewing with satisfaction the course pursued from time to time by their lordships in appointing Naval Engineers to fill vacancies in the various dockyards. trust the practice will be continued, as they are convinced such a course has been, and will be, productive of much good, and benefit the public service."

The claims advanced by the naval engineers, we have no hesitation in stating, are very moderate in their character, and we hope that, not only in common fairness, but for reasons of policy that now the question of naval improvement is occupying a very prominent share of public attention, that the claims of the engineers may meet with that consideration to which the importance of their position entitles them.

The fact is, it is a rather difficult matter for an outsider to comprehend the peculiar phases of naval life,—its distinctions and divisions,—yet, to rightly understand the wants of the Engineers as Naval Officers, these divisions and distinctions, should to a great extent be understood. Now we will believe it will be conceded that most questions involving class improvements are in a great measure, comparative, and Engineers in Her Majesty's navy have a right to compare their position and emoluments with those of the engineers of other governments, and with our own mercantile marine.

We will now briefly refer to the several clauses of the printed statement. The first states that the pay is "insufficient to maintain the position, which their rank," &c., and here perhaps a little consideration of naval rank may not be out of place. Of course, every individual in the Navy, as in the mercantile marine, holds a certain rank or position, supposed to follow from the nature and importance of his duties—but the great distinction of the naval service is in its division into military and civil branches. The first includes Admirals, Captains, Lieutenants, Masters, &c., the latter embraces Engineers, Surgeons, and Paymasters. The former are called Executives, the latter Civilians. The former aspire to command, and to a very great extent monopolise all the honours and rewards the naval service has to offer. The latter—at all events, the engineers—enter the service as a profession, in which at least a respectable livelihood ought to be obtained. The former are more particularly the class to which Lord Palmerston referred when he asserted in the House of Commons, "that the honour of holding a commission in the Navy was to be considered as a fair set off to an acknowledged smallness of pay." The civilian class, however, cannot accept that supposed honour as an equivalent for the hard cash which their labour and skill fairly entitles them to receive.

True the rank which Naval Engineers hold is little more than nominal, for it still leaves them—and, it is to be presumed, necessarily so—as the regulations state "in all such details and matters as relate to the service on which they are employed, subject to the authority of the executive officers of the military branch."

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This nominal or relative rank, therefore, merely gives a certain standing in the ship, while it entails as a consequence an expensive style of messing and uniform.

Engineers, then, few of whom can be expected to possess private means, have a right to ask that their pay shall be such as to enable them to maintain their position, not in extravagance certainly, but fairly and honourably to pay their way, without running into embarrasment, in order to maintain an appearance while in commission, when too often a wife and family is left at home struggling through difficulty and debt, to make "both ends meet."

Again, "other officers of the *Civil* branch are better paid for services neither more responsible nor more arduous. We do not think the Engineers can be charged with presumption in making this comparative statement of the relative importance of the duties of the Civil Officers; for instance, however essential the duties of a surgeon may be, and however necessary the labours of a paymaster, we think it will be readily admitted that in a war ship especially, an Engineer is at least as indispensable as either of the preceding officers. Why then, we may well ask, are they so much better paid? The medical officer (and we should indeed be sorry if we were understood to imply that he is *too* well paid) receives 10*s.* per day the first day he joins the service, while the young engineer commences at 6*s.* The surgeon, on his promotion, which usually takes place in about seven or eight years from his entry into the navy, gets 15*s.* per day, while the Engineer, who seldom gets his promotion to chief in less than twelve or thirteen years, receives but 10*s.* 6*d.* per day. Nor is this injustice removed by length of service, as will be seen from a glance at the highest rates of pay to which each of the classes of civil officers can, under any circumstances, attain.

The pay of a Medical Inspector is £821 per annum, that of a first-class Paymaster is £600 per annum, while the highest pay of an Inspector of Machinery is but £401 per annum. These immense differences must appear the more striking when we consider the importance of the duties devolving upon an Inspector of Machinery of a fleet composed of say only a dozen of our modern line of battle ships, or iron frigates, and yet with all that responsibility his pay is some £200 per year less than that of a first-class Paymaster.

The next point in the printed statement, is that Engineers should be allowed to retire at an earlier age than 60 years. This seems to us a very reasonable request, when we consider the arduous nature of engine-room duties. An Engineer of 60 years of age, implies about 35 or 40 years of active service in all parts of the world, from the coast of Africa to the Arctic regions, and his chances of *enjoying* his half pay after that time are small indeed.

The third clause refers to the accommodation provided for Assistant Engineers. Now let us imagine a young Engineer, of good education and ability, of fair social position, and accustomed to the comforts of a good home, entering the service. His first night on ship-board is almost sufficient to sicken him. A hammock to sleep in, the open deck to undress upon, no partition, even of canvass, to screen him from the sights and sounds of stokers, marines, and sailors, he may well feel disgusted with his new career; yet so difficult is it to provide a remedy for this state of things, that it appears cabin accommodations is only asked for the senior assistant in all ships.

The necessity for making the junior Engineers, Gun-room officers is very great, not because Engineers are willing to admit that an entry into the Gun-room would be an elevation or an honour to themselves, but because while they mess by themselves, other officers in the ship are enabled, and in most instances do, treat them with neglect and indifference. Their rank is at all possible times ignored, and their being banished—as they are in the *Warrior* and *Black Prince*, and many other vessels—to the fore part of the ship, away from all contact with the other officers, is looked upon and urged as a proof that the rank which the Admiralty have given them is really only nominal, and was not intended to confer upon them such claims to considerate treatment, as it does in the case of the other junior officers.

On referring to the classes of junior Engineers and the officers in the Gun-room with whom they rank, it appears that the

Engineer ranks with ..... { Sub-Lieutenant, Second Master, Assistant Paymaster.

Assistant Engineers, 1st & 2nd class, with { Midshipman, Master's Assistant, Naval Cadet, Clerk and Assistant Clerk.

Thus it will be seen that the Assistant Engineers rank with the seniors of the Gun-room Mess; so that, asking that they may be allowed to mess in the Gun-room, is not asking for a rise, but merely to prevent a continuance of that system of exclusiveness on the part of other officers which the present plan of a separate mess enables them to adopt, and seems partly to justify.

The request that the Engineer in charge of the machinery of a ship be allowed to mess in the Ward-room is, we consider, reasonable enough, seeing that he is virtually Chief Engineer of that ship, although his rank in the service may only be Engineer, or, perhaps, First-class Assistant.

The fourth clause needs some further explanation, and this is rendered rather more difficult through what appears to us to be a very absurd change in the titles of Assistant Engineers. Until about a year ago, all Engineers below the rank of Chief, were, rightly enough, called Assistant Engineers of the 1st, 2nd, and 3rd classes. Since then, however, the 3rd class has been abolished, and the titles of "Engineer," Assistant Engineer 1st Class, and Assistant Engineer 2nd Class take their place, but, whilst this alteration certainly produces a considerable amount of confusion when endeavouring to speak or write about Naval Engineers, it is not considered a "grievance." What *is* to be complained of, however, is, that when the young Engineer, who was told before he entered, that he had to serve three years in one grade, two years in another, and three years in a third, &c., has served these stipulated periods, he does not really get his promised promotion for months, and in some cases, we believe, as much as a couple of years pass. There are other officers, we believe, in the same predicament, but the grievance tells much more heavily on the Engineers, in consequence of the number of grades through which they are made to pass, and the number of examinations they have to undergo.

This is really a great grievance, and we have heard of some very excellent Assistants who are getting weary and disgusted with the service from this very cause.

We are informed that there are private and confidential reports sent quarterly from the Captains of H.M. ships to the Admiralty, as to the character and conduct of all officers, and the young Engineer who is kept waiting month after month for his "step" naturally suspects, that in spite of the "good" certificate he may hold, he has been injured in some way by a previous private and confidential report.

It is asked that "all time served from date on entry count for full and half pay." We cannot understand why the younger years of a man's life should be thrown away, and why, if any time at all which an engineer serves ought to be reckoned, the *whole* of it should not be taken into account. At present the engineer who enters the service at 21 years of age, and is lucky enough to arrive at the position of Chief Engineer at the age of 38 or 34, loses entirely at least eight years of his time. Medical officers, on the other hand, count their time from the moment they enter, and we think Engineers should also have that right extended to them. The request is also urged that when an Assistant becomes a commissioned officer he should be allowed a scale of half-pay.

Assistant Engineers are the only class of commissioned officers who are not allowed half-pay, which they consider is an invidious distinction, tending, with other things, to lower them in the estimation of other officers. They are allowed a scale of harbour pay; with the amount of which they do not so much complain, as of the compulsory attendance at one of the dockyards, which it enforces upon them. Other officers, after a three or four years absence, receive their half-pay and are thus able to visit their friends in various parts of the country, recruiting their health, and enjoying some of those social amenities to which, however, the engineer is expected to bid adieu when he enters Her Majesty's Navy, and when it is seen that the half-pay which is granted to an Assistant Surgeon—with whom only the engineer can fairly be compared—is greater even than that allowed to a Chief Engineer, the Assistant Engineer, with his harbour pay and dockyard attendance, has a right to complain.

"Their names also to appear on the Navy List, &c." Here again engineers are the only commissioned officers whose names do not appear on the official lists—published quarterly—and when it is known what frequent changes take place among the junior officers of ships on foreign stations, it is not surprising that the friends of an Assistant Engineer very frequently lose sight of him altogether for years, unless they happen to be in personal communication with him.

We need hardly say anything as to clause 5. It is self-evident, especially when the fact is considered that the average time it takes to arrive at the position of Chief Engineer is thirteen years, and that there must be many who can never arrive at that position at all.

Paragraph 6 is one of great importance, but except the first point, it comes under the old and most important head of pay. More pay is what it means, pay to increase annually instead of every five years, as at present. The first point, however, deserves some consideration; the Inspector of Machinery should, we think, be a distinct rank of itself, carrying with it distinct full and half-pay. At present, however, the Inspector of Machinery, after serving in his admittedly responsible position for any number of years, returns to the scale of half-pay to which he would have been entitled had he remained simply a Chief Engineer. This, were it not an injustice, would be ridiculous, and we think it certainly must be an oversight.

Clause 7, being merely an expression of satisfaction on the part of many engineers, we do not think we need further notice.

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ABSTRACT OF ENGINEER'S LOG OF THE "GREAT EASTERN." SEVENTH VOYAGE FROM LIVERPOOL TO NEW YORK, MAY, 1863.

Date each day, ending at Noon.	PADDLE ENGINES. Revolutions of Engines each day.	Average Revolutions per minute.	Average Pressure of Stm. in Engine-room.	Tons of Coal used each day.	SCREW ENGINES. Revolutions of Engines each day.	Average Revolutions per minute.	Average Pressure of Stm. in Engine-room.	Tons of Coal used each day.	Total quantity of Coal used each day.	Number of Knots run by Paddle Engines.	Number of Knots run by Screw Engines.	Distance run by Ship in Knots.	Latitude.	Longitude.	Course.	Barometer.	Observations on Rolling of Ship. Inclination to windw.	Inclination to leeward	No. of oscil. per min.
			lbs.	Tons			lbs.	Tons	Tons	K.	K.	K.				inches.	deg.	deg.	
May 16 ...	565	6·0	20	35	3,150	...	17½	50	85	17	19	17	...	...	Various.	...	...	...	...
May 17 ..	10,627	9·32	21	107	44,140	34·4	17½	136	243	251	279	150	51·42 N.	8·7 W.	S. 82·52 W.	...	...	...	...
May 18 ..	13,103	9·0	21	115	51,000	34·4	17½	164	279	335	367	282	57·7 N.	15·35 W.		30·10	...	...	...
May 19 ..	13,930	9·5	21	123	51,080	34·7	17½	167	290	346	366	306	50·41 N.	23·32 W.	S. 85·4 W.	30·04	...	...	...
May 20 ..	13,912	9·5	21	129	51,580	35·2	17½	167	296	344	371	303	49·30 N.	31·10 W.	S. 76·27 W.	30·04	...	...	...
May 21 ...	14,596	10·0	21	116	51,210	35·4	17½	177	293	362	376	284	48·17 N.	38·6 W.	S. 74·55 W.	29·09	...	...	...
May 22 ..	13,113	9·25	21	127	50,220	34·5	17½	176	303	335	362	304	46·11 N.	44·48 W.	S. 65·16 W.	29·06	...	...	...
May 23 ...	14,527	10·0	21	126	50,940	34·6	17½	176	302	365	365	312	43·39 N.	51·8 W.	S. ·62 W.	29·03	...	...	...
May 24 ..	13,430	9·0	21	121	51,930	35·34	17½	181	302	326	371	250	42·13 N.	57·32 W.	S. ·73 W.	29·40	...	...	...
May 25 ...	13,140	9·0	21	113	50,920	35·0	17½	177	290	326	371	298	39·47 N.	63·48 W.	S. ·82 W.	29·62	...	...	...
May 26 ...	13,519	9·3	21	115	53,190	36·5	17½	182	297	334	379	292	39 53 N.	68·20 W.	N. 88·49 W.	29·60	...	...	...
May 27 ...	12,485	9·4	21	118	47,470	36·0	17½	174	292	312	348	252	Steering by the land, various.			...	...	...	...
May 28 ..	2,091	8·0	21	20	8,070	31·0	17½	32	52	51	47	51	...	...	...	...	...	...	...
Total	149,038	9·35	21	1365	564,900	35·45	17½	1959	3324	3704	4021	3101	...	...	...	...	...	...	...

Actual time of steering 11 days 1 hour and 30 minutes; density of water in boilers, 1½; vacuum in paddle engines, 25; ditto in screw engines, 25; extreme diameter of paddle wheels, 50ft.; effective diameter, 48ft. = 150·79ft. each revolution; screw, 44ft. pitch; average distance run per hour, 11·7 knots; immersion on leaving Liverpool, 23ft. 11in forward; 26ft. 2in. aft.; immersion on arriving at New York, 21ft. 10in. forward; 23ft. 8in. aft.; slip of paddle wheel, 19·44 per ce.nt.; ditto screw, 29·66 per cent.; daily average consumption of coals per paddle engines 124 tons; ditto screw engines 178 tons; total daily consumption, 302 tons.

General Remarks.

May 16, at 9.45 A.M., started paddle and screw engines ahead slow; 10.1 A.M., full speed; at 11.45 A.M., stopped engines off Bell Buoy, waiting for steam tender.
May 17, at 12.55 P.M., discharged pilot off Bell Buoy; at 1 P.M., started paddle and screw engines ahead full speed; at 7.45 P.M., weigh shaft of Port Forward, paddle engine broke, stopped paddle engines, and disconnected slide of said engine; at 11.45 P.M., started paddle engines ahead full speed; paddle engines stopped four hours; working with three engines.
May 18, light W. breeze and heavy swell.
May 19, light N.N.E. breeze and heavy sea running.
May 20, light S.E. by S. breeze, fore and aft sails set.
May 21, fresh S.S.E. breeze, fore and aft and square sails set.
May 22, fresh N.N.W. breeze, and heavy sea running. At 6.30 A.M., the bottom escape valve of paddle port after cylinder got gagged, stopped paddle engines, and cleared it; 7 A.M., started paddle engines ahead full speed.
May 23, fresh N.N.E. breeze, fore and aft sails set, screw engines racing, passed several icebergs.
May 24, strong N. breeze, fore and aft sails set, heavy sea running.
May 25, fresh N.W. breeze and heavy sea running, fore, aft, and square sails set.
May 26, light N.N.W. breeze, sea smooth.
May 27, at 1 A.M., stopped paddle and screw engines to take soundings; at 2.40 A.M., started paddle and screw engines ahead full speed; at 4.42 A.M., stopped paddle and screw engines to take pilot on board off Montauk Point; at 5.55 A.M., started paddle and screw engines ahead full speed; at 6.20 A.M., slowed paddle and screw engines, dense fog; at 6.40 A.M. full speed; at 9.10 A.M., stopped paddle and screw engine to take Custom House officers on board; at 9.20 A.M., full speed.
May 28, at 3.30 P.M., paddle and screw engines working easy; at 4 P.M. paddle and screw engines working slow; at 4.30 P.M., stopped paddle and screw engines, and dropped anchor in Flushing Bay.

ABSTRACT OF ENGINEER'S LOG OF THE "GREAT EASTERN." SEVENTH VOYAGE FROM NEW YORK TO LIVERPOOL, JUNE, 1863.

Date each day, ending at Noon.	PADDLE ENGINES. Revolutions of Engines each day.	Average Revolutions per minute.	Average Pressure of Stm. in Engine-room.	Tons of Coal used each day.	SCREW ENGINES. Revolutions of Engines each day.	Average Revolutions per minute.	Average Pressure of St'm. in Engine-room.	Tons of Coal used each day.	Total quantity of Coal used each day.	Number of Knots run by Paddle Engines.	Number of Knots run by Screw Engines.	Distance run by Ship in Knots.	Latitude.	Longitude.	Course.	Barometer.	Observations on Rolling of Ship. Inclination to windwd.	Inclination to leeward	No. of oscil. per min.
			lbs.	Tons			lbs.	Tons	Tons	K.	K.	K.				inches.	deg.	deg.	
June 7 ...	7,262	...	...	87	25,700	...	17½	141	228	...	...	120	Steering by the land.			...	...	...	...
June 8 ...	12,142	9·0	21	115	47,530	34·7	17½	172	287	307	346	250	40·15 N.	65·24 W.	N. 81·23 E.	29·50	...	...	...
June 9 ...	11,721	8·3	21	116	48,990	34·7	17½	173	289	288	354	270	41·25 N.	59·38 W.	N. ·75 E.	29·90	...	...	...
June 10 ...	12,176	8·6	21	119	49,430	35·0	17½	179	298	305	361	284	43·20 N.	53·38 W.	N. ·66 E.	29·70	...	...	...
June 11	12,026	8·62	21	123	47,370	34·0	17½	177	300	300	342	268	44·43 N.	47·38 W.	N. ·72 E.	29·07	...	...	...
June 12	12,928	9·2	21	120	49,560	35·2	17½	178	298	320	360	289	46·52 N.	41·21 W.	N. 63·19 E.	29·06	...	...	...
June 13	13,167	9·3	21	117	50,310	36·0	17½	173	290	323	367	297	48·21 N.	34·26 W.	N. 72·46 E.	29·05	...	...	...
June 14	12,488	8·55	21	108	40,050	35·0	17½	148	256	332	274	267	49·30 N.	27·53 W.	N. 75·2 E.	29·07	...	...	...
June 15	13,600	9·7	21	123	49,140	35·0	17½	178	301	341	359	294	50·7 N.	20·24 W.	N. 82·46 E.	29·05	...	...	...
June 16	14,650	10·4	21	123	46,300	35·0	17½	173	296	367	359	312	50·39 N.	12·24 W.	N. 83·56 E.	29.06	...	...	...
June 17	14,499	10·42	21	121	46,990	35·0	17½	173	294	359	353	325	Steering by the land, various.			29·03	...	...	...
June 18	5,052	10·6	21	33	16,900	35·0	17½	58	91	124	120	90	...	...	...	...	...	...	...
Total	141,711	9·51	21	1305	521,170	35·3	17½	1923	3228	3366	3695	3066	...	...	...	...	...	...	...

Actual time of steaming from Montauk Point to Bell Buoy, 10 days 6 hours 6 minutes. From New York to Montauk Point, 12 hours 15 minutes. Density of water in boilers, 1½; vacuum in paddle engines, 25; vacuum in screw engines, 25; extreme diameter of paddle wheel, 50ft.; effective diameter 48ft. = 150·79ft. each revolution; pitch of screw, 44ft.; average distance run per hour, 12·47 knots; immersion on leaving New York, 27ft. forward,—aft. 29ft. 5in.; ditto on arrival at Liverpool, 23ft. 6in. forward,—25ft. 10in. aft.; slip of paddle wheels, 9·8 per cent.; slip of screw, 17·25 per cent.; average daily consumption of coals by paddle engines, 122 tons; ditto by screw engines, 178 tons; total daily consumption of coals, 300 tons.

General Remarks.

June 7, at 12.15 p.m., started paddle and screw engines ahead slow, engines working very easy; at 11p.m., stopped paddle and screw engines and dropped anchor; dense fog; at 5.30 a.m., started paddle and screw engines ahead slow; at 6.40 a.m., stopped paddle and screw engines to discharge pilot off Montauk Point; at 7.10 a.m., full speed, the paddle and screw engines working very easy, 12 hours and 15 minutes. Paddle and screw engines working full speed 5 hours, from time of pilot leaving till noon.
June 8, Light E.N.E. breeze, sea smooth, square sails set, dense fog, engineers standing by paddle and screw engines; paddle and screw engines stopped 20 minutes to take soundings.
June 9, Fresh W., S.S.E., S.E. variable breeze and heavy sea running.
June 10, Light S.E. to S.W., breeze and heavy swell, dense fog; engineers standing by paddle and screw engines.
June 11, Light S.W. breeze and heavy swell, dense fog; engineers standing by paddle and screw engines; stopped 20 minutes to take soundings.
June 12, Fresh W. breeze, square sails set, and heavy sea running, dense fog; engineers standing by paddle and screw engines.
June 13, Fresh W.N.W. breeze, and heavy sea running, square sails set, screw engines racing.
June 14, Fresh N.W. to S.W. breeze and heavy sea running, square sails set, screw engines racing; at 5.33 a.m., the adjusting slab of crosshead of Port Forward screw engine broke, stopped engines, and fitted a wood substitute; at 10 a.m., started screw engines; screw engines stopped, 4½ hours; speed of ship by paddle engines alone, 7 knots per hour.
June 15, Light breeze, sea smooth, fore and aft sails set.
June 16, Light breeze, sea smooth, fore and aft sails set.
June 17, at 4 p.m., stopped paddle and screw engines to put a corpse overboard; at 4.40 p.m., full speed; paddle and screw engines stopped 40 minutes; light breeze, sea smooth.
June 18, at 4.43 p.m., stopped paddle and screw engines to take pilot on board; at 4.55 p.m., started engines ahead full speed; at 8 p.m., stopped engines off Bell Buoy to wait for tide; all particulars of engines taken up to this time.

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ROYAL INSTITUTION OF GREAT BRITAIN,

ON SCIENTIFIC EXPERIMENTS IN BALLOONS,

By JAMES GLAISHER, ESQ., F.R.S.

In the introductory part of the discourse, Mr. Glaisher gave a brief history of aërostation, from the discovery of the fire-balloon in the year 1782, by the two brothers Montgolfier, noticing some of the principal ascents made with fire-balloons. He then spoke of the discovery of Cavendish in 1776, *viz.*, that hydrogen gas was fully ten times lighter than common air; when it immediately occurred to Dr. Black, of Edinburgh, that if so, a thin bladder filled with this gas ought to rise of itself: yet a period of several years elapsed before this obvious property was applied to the inflation of balloons; not in fact till the success of the fire-balloon was established. He then spoke of the more remarkable ascents and experiments which were made with air-balloons within a few years of its discovery, and remarked, that the result of the several experiments having proved that the balloon would raise great weights in the air, and remain for a long time thus suspended, caused a general desire to navigate the lofty regions of the atmosphere, and to pursue meteorological and other investigations in those regions, and the invention of the balloon was looked upon as likely to be followed by great consequences. He then spoke of the different ascents which have been made in the interests of science: the first of which was that of Mr. Boulton, well known as the partner of the famous Watt, who constructed a balloon to which a match and serpent were attached, that the gas might explode in the air. The object was to determine whether the reverberating sound of thunder was caused by echo or by successive explosions; the point remained unsettled, owing to the shouting of the people; but it was thought that the sound did resemble thunder.

This experiment was made on December 26, 1784. No further experiments were made, so far as he knew, till the beginning of the present century, when in the years 1803 and 1804, Mr. Robertson made three ascents from St. Petersburg, for the purpose of making magnetical and other experiments.

On August 23, 1804, MM. Gay-Lussac and Biot ascended from Paris for a similar purpose; they attained an altitude of 13,000ft., and found no difference in their experiments in electricity, magnetism, and galvanism from those made on the earth.

On September 15, Gay-Lussac ascended alone to a height of 22,977ft.; he found that the temperature declined from 82° to 15°; that the sky was deep blue; that the time of horizontal vibration of a magnet was shorter with elevation.

In 1806, Carlo Brioschi, Astronomer-Royal at Naples, endeavoured to ascend higher than Gay-Lussac; the balloon burst, but its remnant happily checked the rapidity of the descent.

A period of forty-four years followed, during which no systematic attempts were made to take scientific observations by means of balloons.

In 1850, MM. Bixio and Barral inflated a balloon with hydrogen gas, in the gardens of the Observatory at Paris, with the intention of ascending to a height of from 30,000 to 40,000ft.; in their first ascent they ascended to a height of 19,000ft., and descended to the earth in 47 minutes; they passed through a mass of cloud 9000ft. in thickness.

In their second ascent, clouds were reached at 7000 or 8000ft., which proved to be 15,000ft. in thickness; they never, in fact, passed out of the clouds; for when they were 23,000ft. high, they began to descend, owing to a rent in the balloon.

Mr. Welsh's experiments were made in the year 1852: on August 17 and 26, October 21, and November 10, the respective heights attained in these were 19,500ft., 19,100ft., 12,640ft., and 22,930ft.: a great number of observations were made, from which the following law regarding the decline of temperature with elevation was deduced:—

"That the temperature of the air decreases uniformly with the height above the earth's surface, until at a certain elevation, varying on different days, the decrease is arrested, and for a space of 2000 or 3000ft. the temperature remains nearly constant, or even increases by a small amount: the regular diminution being afterwards resumed and generally maintained at a rate slightly less rapid than in the lower part of the atmosphere, and commencing from a higher temperature than would have existed but for the interruption noticed."

These results, as well as those found by Gay-Lussac relative to the decline of temperature with increase of elevation, appeared to confirm the law which theory, based upon observations upon mountain sides, assigns for the gradation of temperature; *viz.*, a decrease of one degree of temperature for every increase of 300ft. Up to the present time therefore the high expectations entertained on the discovery of the balloon have never been realized.

The speaker then proceeded to state, that since the formation of the British Association, grants of money have been made for the purpose of pursuing these inquiries; but with the exception of those by Mr. Welsh, none have been made.

In the year 1861, another grant of money was made, and a committee appointed to carry out experiments by means of the balloon, and the task of making these experiments was undertaken by the speaker.

The primary object of the experiments with which he was entrusted were:—

The determination of the temperature of the air and its hygrometrical states at different elevations up to five miles.

To compare the readings of an aneroid barometer with those of a mercurial barometer up to five miles.

To determine the electrical state of the air.

To determine the oxygenic state of the air by means of ozone papers.

To determine the time of vibration of a magnet on the earth, and at different distances from it.

To determine the temperature of the dew point by Daniell's Dew Point Hygrometer, Regnault's Condensing Hygrometer, and by the use of the Dry and Wet Bulb Thermometers as ordinarily used, and by their use when under the influence of the aspirator, so that considerable volumes of air are made to pass over their bulbs, at different elevations, as high as possible, but particularly up to those heights where man may be resident or where troops may be located, as in the high lands and plains of India, with the view of ascertaining what confidence may be placed in the use of the Dry and Wet Bulb Thermometers, by comparison with the results as found from them and with those found directly by Daniell's and Regnault's Hygrometers; and to compare the results as found from the two hygrometers together.

To collect air at different elevations.

To note the heights and kind of clouds, their density and thickness at different elevations.

To determine the rate and directions of different currents in the atmosphere.

To make observations on sound.

To note atmospherical phehomena in general, and to make general observations.

The speaker then described the method of managing a balloon, spoke briefly of the several ascents already made, and then proceeded to speak of some of the results.

Speaking of the ascent on July 17, the departure of the temperature from a regular progression was very remarkable. Below the cloud the decrease was nearly uniform; on passing above it there was an increase of 6°; the decrease was then resumed, and the temperature was 26° at 10,000 feet, and continued at this reading till 13,000 feet had been passed; a very remarkable increase then took place, and at 19,500 feet a temperature of 42° was registered, and then declined rapidly to 16° at five miles. In descending, a disturbance from a regular increase was met with at 24,000 ft., and continued to 17,000ft.; at 13,000ft. clouds were reached and no observations were made below 10,000ft.

The temperature of the dew point approached that of the air in the cloud but did not touch it, and then separated more and more until at the highest point there was almost an entire absence of moisture.

On August 18, the temperature of the air decreased as usual on leaving the ground, until at the height of 4000ft. the rapidity of the decrease was checked and a warm current of air was met with and continued to 11,000ft.; the balloon then descended and passed through the same warm current extending to the same limits, and again passed through it on its re-ascension at about the same height, and extending to 14,000ft., when the regular diminution was resumed and continued to the highest point; on descending, the same warm current was met with, and continued till the clouds were entered at 6500ft., which caused another interruption in the regular increase of temperature, as is usual on entering cloud.

In the ascent on September 5, on passing out of the cloud there was an increase of temperature of 9°; and then no interruption was met with till a height of 15,500ft. was reached, when a warm current of air was reached, and continued to 24,000ft; then a regular decrease was experienced till the highest point was reached.

On descending, the same warm current was encountered between 22,000 and 23,000ft.; and a similar interruption, but to a greater amount, was experienced till the balloon had descended to about the same height as it was first met with on ascending. After this there was no further interruption till the descent was completed.

A table was then formed from all the other observations, showing the decrease of temperature for successive increases of elevation of 1000ft. The results are as follows:—

When the Sky was Cloudy.

	Ft.	Ft.	Deg.			Deg.	Ft.
From	0	to 1000	was 4·7	from 7	experiments, or	1	in 213
„	1000	to 2000	was 4·2	from 7	„	1	in 239
„	2000	to 3000	was 4·1	from 10	„	1	in 244
„	3000	to 4000	was 3·7	from 10	„	1	in 271
„	4000	to 5000	was 3·1	from 6	„	1	in 323

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But When the Sky is partially Clear.

	Ft.		Ft.	Deg.			Deg.	Ft.
From	0	to	1000	was 7·2	from 5	experiments, or	1 in	139
„	1000	to	2000	was 5·3	from 5	„	1 in	189
„	2000	to	3000	was 4·6	from 5	„	1 in	254
„	3000	to	4006	was 3·4	from 6	„	1 in	295
„	4000	to	5000	was 2·7	from 7	„	1 in	370

These results differ considerably from those formed in a cloudy sky, and doubtless the difference between experiments carried on under a cloudless sky would differ still more. They do not at all confirm the theory of a decline of 1° of temperature in 300 feet.

The Decrease of the Temperature of the Air, at heights exceeding 500 feet.

	Ft.		Ft.	Deg.			Ft.
From	5,000	to	6,000	was 2·8	from 10	experiments, or 1 in	357
„	6,000	to	7,000	was 2·8	from 8	„ 1 in	357
„	7,000	to	8,000	was 2·7	from 8	„ 1 in	370
„	8,000	to	9,000	was 2·6	from 8	„ 1 in	384
„	9,000	to	10,000	was 2·6	from 8	„ 1 in	384
„	10,000	to	11,000	was 2·6	from 8	„ 1 in	384
„	11,000	to	12,000	was 2·6	from 6	„ 1 in	384
„	12,000	to	13,000	was 2·5	from 6	„ 1 in	400
„	13,000	to	14,000	was 2·2	from 6	„ 1 in	455
„	14,000	to	15,000	was 2·1	from 9	„ 1 in	477
„	15,000	to	16,000	was 2·1	from 9	„ 1 in	477
„	16,000	to	17,000	was 1·9	from 9	„ 1 in	527
„	17,000	to	18,000	was 1·8	from 9	„ 1 in	556
„	18,000	to	19,000	was 1·8	from 9	„ 1 in	556
„	19,000	to	20,000	was 1·5	from 9	„ 1 in	667
„	20,000	to	21,000	was 1·3	from 9	„ 1 in	771
„	21,000	to	22,000	was 1·3	from 9	„ 1 in	771
„	22,000	to	23,000	was 1·0	from 9	„ 1 in	1000
„	23,000	to	24,000	was 1·3	from 2	„ 1 in	771
„	24,000	to	25,000	was 1·1	from 2	„ 1 in	909
„	25,000	to	26,000	was 1·0	from 1	„ 1 in	1000
„	26,000	to	27,000	was 1·0	from 1	„ 1 in	1000
„	27,000	to	28,000	was 0·9	from 1	„ 1 in	1012
„	28,000	to	29,000	was 0·8	from 1	„ 1 in	1050

These results follow almost in sequence with those found with a partially clear sky; and together show that a change takes place of 1° of temperature in 139 feet near the earth, and only in 1000 feet at the height of 30,000 feet, and plainly indicates that the decline of 1° of temperature must be abandoned.

Treating the observations for determining the degrees of humidity of the air in the same way, the following are the results:—

When the Sky was cloudy, saturation being considered as 100,

On the earth the degree of humidity was			78	from 5	experiments.
At the height of	1000	the degree of humidity was	76	„ 9	„
„	2000	„	77	„ 11	„
„	3000	„	75	„ 11	„
„	4000	„	80	„ 10	„
„	5000	„	81	„ 5	„
„	6000	„	82	„ 3	„

The law of moisture here shown is an almost uniform state of humidity to the height of 3000 feet, viz., 76·5; then a decrease on the next 1000 feet, and an increase to 83 and 82 at 5000 and 6000 feet.

When the Sky was partially clouded.

On the ground the degree of humidity was			63	from 4	experiments.
At the height of	1000	the degree of humidity was	68	„ 5	„
„	2000	„	77	„ 5	„
„	3000	„	76	„ 5	„
„	4000	„	76	„ 7	„
„	5000	„	69	„ 6	„
„	6000	„	68	„ 6	„

At heights exceeding 6000 feet, the following were the results:—

	Ft.				
At the height of	7,000	the degree of humidity was	64	from 7	experiments.
„	8,000	„	58	„ 7	„
„	9,000	„	52	„ 7	„
„	10,000	„	82	„ 7	„
„	11,000	„	48	„ 5	„
„	12,000	„	48	„ 8	„
„	13,000	„	43	„ 5	„
„	14,000	„	58	„ 2	„
„	15,000	„	53	„ 3	„
„	16,000	„	45	„ 3	„
„	17,000	„	33	„ 3	„
„	18,000	„	21	„ 2	„
„	19,000	„	36	„ 2	„
„	20,000	„	33	„ 1	„
„	21,000	„	12	„ 1	„
„	22,000	„	31	„ 1	„
„	23,000	„	16	„ 1	„

The laws of moisture here indicate a humidity near the ground less by 15 with a partially clear sky, than in a cloudy sky; starting with 63 in the former state on the ground, increasing to 77 at 300 feet high; then nearly constant to 5000 feet, when it abruptly decreased to 69 and 68 at 5000 and 6000 feet, and then decreased nearly evenly at the rate of 5 in 1000 feet, till at 9000 and 10,000 feet it was 52; the degree then constantly decreased till at a height exceeding 25,000 feet it was less than 10, and it would seem that at higher elevations there was an almost entire absence of water. These seem to be the general laws; but this regular diminution is evidently very often interrupted, and strata of moist air may exist, or be passing at different elevations, even up to 20,000 feet, of some thickness.

Electrical State of the Air.—In the ascent on July 17, the air was found to be charged with positive electricity, becoming less in amount with increased elevation, till at the height of 23,000 feet, the amount was too small for observation. The instrument was broke in the descent, and was not afterwards used.

Time of a Vibration of a Magnet.—The general result of all the experiments is, that the magnet vibrates in a somewhat longer interval of time at higher elevations than on the earth. This result is contrary to that found by Guy-Lussac in 1804.

On the Propagation of Sound.—From observation made in the different ascents, it was learnt that different notes and sounds pass more readily through the air than others; for instance, the barking of a dog and the whistle of a railway engine have been heard at a height of more than two miles, whilst the shouting of several thousand people cannot be heard at the height of one mile.

On the Oxygenic Condition of the Atmosphere.—On July 17, the test papers by Moffat and Schönbein were untinged by colour throughout the journey; and the same result was found during the ascent on July 30.

On August 10, Mr. Glaisher received a letter from Dr. Moffat, of Hawarden, expressing his surprise at this result, inasmuch as it has always been received as a theory, that ozone increases in quantity with increased elevation.

In consequence of this, Mr. Glaisher went to Dr. Moffat, at Hawarden, and requested him to make some papers, which he did, and these papers were used on August 18, together with some prepared by Messrs. Negretti and Zambra, and some prepared according to Schönbein's formula; and at 22,000ft. the coloration was 4 on a scale whose deepest tinge is 10, whilst those prepared by Schönbein were coloured to on the same scale, and those by Negretti and Zambra were uncoloured; in consequence of this, the preparation of the papers by Messrs. Negretti and Zambra has been stopped.

Physiological Observations.—On July 17, before starting, the number of Mr. Coxwell's pulsations were taken, and found to be 74 in one minute; and Mr. Glaisher's 76 in one minute.

At a height of 17,000ft., Mr. Glaisher's had increased to 100, and Mr. Coxwell's to 84; and on reaching the ground, the number was 79 with both gentlemen.

On August 21, no observations were taken before starting. At the height of 1000ft., the following results were obtained:—

Mr. Coxwell	96	per minute.
Mr. Ingelow	80	„
Capt. Percival	90	„
At 11,000 feet—		
Mr. Coxwell	90	in a minute.
Mr. Ingelow	100	„
Capt. Percival	88	„
Mr. Glaisher	88	„
Master Glaisher	89	„
At 14,000 feet—		
Mr. Coxwell	94	per minute.
Mr. Glaisher	98	„
Mr. Ingelow	112	„
Capt. Percival	78	„
Master Glaisher	89	„

The pulsations of Capt. Percival were so weak that he could scarcely count them; whilst those of Mr. Coxwell he considers had increased in strength.

From these results it will be seen that diminished pressure exercises a different influence upon different individuals.

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On July 17, at 19,000 feet the hands and lips were noted as being dark-blue, not the face. At the height of four miles the palpitations of the heart were audible, and the breathing was affected.

On August 18, the hands and face were blue at the height of 23,000 feet.

On September 5, at the height of about 29,000 ft, Mr. Glaisher became unconscious, and at 35,000 feet Mr. Coxwell lost the use of his hands. At 29,000 feet on descending, Mr. Glaisher began to recover, and at 25,000 feet the observations were resumed.

The general results of these eight ascents are :—

1st. That the temperature of the air does not decrease uniformly with the height above the earth's surface, and consequently the theory of a decrease of 1° of temperature for an increase of elevation of 300ft. must be abandoned. In fact, more than 1° declined in the first hundred feet when the sky was clear, and not so much as 1° in 1000ft. a height exceeding five miles.

These experiments are the first to yield any definite information on the subject; more experiments are required to settle the law satisfactorily, but its effect on the laws of refraction will be great: all the elevations of the balloon are to a certain extent erroneous, for it has never happened that the mean of the extremities has given the mean of the whole column of air.

2nd. The degree of humidity decreased wonderfully with the height till at about five miles there was scarcely any aqueous vapour at all.

3rd. That an aneroid barometer can be made to read correctly, to the first place of decimals certainly, and to the second place of decimals probably, to a pressure as low as 7in.

4th. That a dry and wet bulb thermometer can be used effectively up to any height on the earth's surface where man may be located.

5th. That the balloon does afford a means of solving with advantage many delicate questions in physics.

ON SOME CHEMICAL AND PHYSICAL PROPERTIES OF SOILS, AND THE PRODUCTIVE POWERS OF THE SOILS OF ENGLAND.

In all fertile soils we find variable quantities of organic matter—ready-formed ammonia, nitric acid, potash, soda, lime, magnesia, oxides of iron, chlorine, phosphoric, sulphuric, and silicic acids; in short, all the mineral matters which are found in the ashes of plants. These minerals, or ash constituents, it need scarcely be observed, are not merely accidental but essential materials, without a proper supply of which no plant can grow luxuriantly and come to full maturity. In one sense all are equally important; for the absence or deficiency in the soil of one, be it lime or potash, phosphoric or silicic acid, is detrimental to the luxuriant development of the vegetable organism. No one who has given the slightest consideration to this subject will hesitate to give assent to this mineral theory.

It is natural to connect the productiveness of soils with the proportion of ash-constituents of plants which they contain; but although in some cases a soil may be unproductive on account of the absence or deficiency of lime or potash or phosphoric or any other mineral matter which enters into the composition of plants, in the majority of cases the chemical analysis of different soils affords little or no indication of their relative productive powers.

The combinations in which the mineral constituents of plants exist in the soil, their unequal or uniform distribution in the surface, the composition and physical condition of subsoil, the relative depth of both, the porosity of the land, and especially the power of absorbing and retaining as well as modifying in a variety of ways the crude manuring agents which are applied to the land, unquestionably are intimately connected with the great variations which we notice in the agricultural capabilities of different soils.

Before the publication of Liebig's celebrated "Chemistry in its Application to Agriculture," a work which has given the death-blow to the humus theory, the fertility or barrenness of a soil was generally considered to depend entirely upon its physical properties and the presence or deficiency of humus. Soon after the publication of Liebig's writings, scientific men fell into the opposite extreme, and expected, the bare chemical analysis of a soil and the ash-analyses of plants would enable them to discover at once the means of restoring the fertility of land, or to improve it by certain purely mineral manuring mixtures, and to grow on it, irrespective of its natural adaptation to the growth of particular crops, any kind and almost every amount of agricultural produce.

These unphilosophical views have rendered agricultural chemistry less popular than formerly, but also more scientific and more directly useful to the enlightened agriculturist.

A new direction to chemico-agricultural enquiries was given about ten years ago by Professor Way's highly important researches on the absorptive powers of soils for manure. Professor Way's investigations originated in an observation of Mr. Thompson, of Kirby Hall, York, who found that soils have the faculty of separating ammonia from its solution.

On passing solutions of ammonia through different soils, Way found that all possess the power of retaining ammonia, some more, some less. He also observed that potash, lime, magnesia, and phosphoric acid are absorbed by all soils to a considerable extent.

Still more important are his experiments, which prove that cultivated soils not only absorb free alkalies and acids, but have likewise the power of separating ammonia, potash, and other bases from their saline combinations.

Professor Way principally operated with simple salts: it may therefore be urged, that it by no means follows, as a necessary consequence, that because a soil absorbs ammonia when a solution of sulphate of ammonia is passed through it, the same absorption will take place when an ammoniacal salt mixed with some dozen other substances is filtered through it.

I therefore operated with complex liquids, and already, in 1857, published several filtration experiments in the Journal of the Royal Agricultural Society.

These and many subsequent experiments have shown that all soils not only possess the power of absorbing and retaining potash, ammonia, phosphoric and silicic acid, and other mineral matters, but also of modifying in the most varied way the composition of complex saline solutions which are passed through them.

The following table shows the results obtained in filtering the same kind of liquid manure through two very different soils, taken from the neighbourhood of Cirencester.

An imperial gallon contains :—	No. 1. Calcareous clay soil.			No. 2. Ferruginous sterile sandy soil.	
	Before contact with soil.	After contact with soil.	Loss or gain.	After contact with soil.	Loss or gain.
Water and volatile ammonia compounds	69,888·14	69,886·60	—1·54	69,894·25	+ 6·11
Containing :—					
Ammonia, as carbonate & humate of ammonia	(35·58)	(20·81)	—14·77	—(33·15)	— 2·43
Organic matters	20·59	34·77	+14·18	—(25·06)	+ 4·47
Containing nitrogen.....	(1·49)	(1·84)	+ ·35	— (1·70)	— ·09
Equal to ammonia	(1·81)	(2·23)	+ ·42	— (1·70)	— ·11
Inorganic matters.....	(91·27)	(78·63)	—12·64	—(80·69)	—10·58
Consisting of :—					
Soluble silica	2·34	·70	— 1·64	— 5·10	+ 2·76
Oxide of iron.....	none	2·55	+ 2·55	— 2·07	+ 2·07
Lime	11·48	22·42	+10·94	— 8·03	— 3·45
Magnesia	2·87	1·17	— 1·70	— ·74	— 2·13
Potash.....	16·92	3·40	—13·52	—12·01	— 4·91
Chloride of potassium ...	2·74	none	— 2·74	none	— 2·74
Chloride of sodium	40·35	33·31	— 7·04	—39·25	— 1·10
Phosphoric acid.....	4·83	·60.	— 4·93	— 1·92	— 2·91
Sulphuric acid	3·94	2·88	— 1·06	— 3·67	— ·27
Carbonic acid, and loss...	5·80	11·60	+ 5·80	— 7·90	+ 2·10
	70,000·00	70,000·00		70,000·00	

The preceding analytical results, amongst other particulars, show :—

1. That the calcareous clay soil absorbed about six times as much ammonia from the liquid manure, as the sterile sandy soil.
2. That the liquid manure in contact with the calcareous clay soil, becomes much richer in lime; whilst during its passage through the sandy soil, it becomes purer in lime.
3. That the calcareous soil absorbed much more potash than the sand soil.
4. That chloride of sodium, in conformity with the results of other observers, was not absorbed to any extent by either soil.
5. That both soils removed from the liquid most of the phosphoric acid.
6. That the liquid in passing through the calcareous soil becomes poorer; aad, on the other hand, in passing through the sandy soil becomes richer in soluble silica.

The property of soils to store up food for plants is thus not confined to one particular kind of fertilizing matter, but it applies to them all, and manifests itself in a way which is modified by the composition of the soil.

In these, and in all other experiments which I have since made, the ammonia, potash, phosphoric acid, and other fertilizing matters contained in a solution were never completely absorbed by any soil, however weak or consentrated the solutions were that were filtered through the soil. Iudeed, if the solution of saline matters which are brought into contact with soil are very dilute, scarcely any absorption of ammonia, potash, or phosphoric acid takes place.

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Sewage of towns, on account of the very diluted condition in which this liquid is usually found, in percolating through a soil scarcely leaves any of its soluble constituents in the soil in a fixed or less soluble form, although the soil possesses in a high degree the power of absorbing and retaining soluble fertilizing matters.

All soluble saline matters, however useful or necessary they may be, impede the rapid growth of plants, if they are presented too abundantly or in too concentrated a solution to the roots of plants. One of the functions of the soil appears to be to transform such readily soluble compounds into combinations so little soluble in water, that they pass in common life as insoluble, but which are still sufficiently soluble to supply the growing plant with the necessary amount of mineral food in a state of solution.

This beautiful power of soils thus not only effectually prevents the waste in fertilizing matters which heavy rains would otherwise occasion, but also rectifies in a great measnre any misapplication which may be made of concentrated soluble fertilizers.

The power of soils to modify manuring matters depends in a great measure on the chemical composition of the soil, and also on the concentration of the liquid and the quantity of soluble fertilizing matters which is incorporated with that portion of the soil which is penetrated by the roots of plants. Hence the effect which one and the same manure is capable of producing varies greatly in different soils, and also with a rainy or dry season.

The office of the soil is not merely to supply mineral food to plants, but also to manufacture, so to say, crude food into a condition fit for assimilation; to prevent injury to the living plant by too large an accumulation of soluble matters in the surface soil; to store up for future use such an excess; to diffuse it equally in that portion of the land reached by the roots of plants; and to modify it in conformity with the requirements of our crops, in a manner differing with each description of land.

Respecting the causes of the absorbing properties of soils, the opinions of chemists are divided.

Liebig regards this power as analogous to, if not identical with the physical power which charcoal possesses in retaining colouring matters, and consequently considers the soluble fertilizing matters which are brought into contact and absorbed either wholly or partially by the surface soil, as present in what he calls a physical state of combination.

Professor Way, on the other hand, believes the absorption to be due to the presence of certain double silicates of alumina in the soil. Thus, for instance, the double silicate of alumina and soda when brought into contact with lime, according to Way, parts with its soda and takes up lime. When the double silicate of alumina and lime thus formed is brought into contact with magnesia, lime passes into solution, and a double silicate of alumina and magnesia is formed; this in its turn is decomposed by a salt of potash; and the double silicate of alumina and potash by the salt of ammonia; thus finally, a double silicate of alumina and ammonia is produced.

Such displacements indeed took place on repeating Way's experiments: but when a preparation made after Professor Way's directions, and containing silica, alumina, and ammonia, is mixed with an excess of a solution containing a salt of potash, ammonia passes into the solution and potash is absorbed by the preparation. From a similar preparation containing silica, alumina, and potash, an excess of a solution of a lime salt removes potash, and lime becomes absorbed.

But as in no case I have been able to notice a substitution of one base for another in equivalent proportions, and no double silicate of a definite composition can be produced by Mr. Way's plan of operation, and the existence of such definite compounds in soils has never been demonstrated, I would suggest a different cause or causes which are in operation when potash, ammonia, and other fertilizing matters are fixed in the soil.

The absorption of soluble fertilizing matters by soils I believe may readily be explained by a reference to well-known chemical facts. The absorption of soluble phosphates or phosphoric acid is readily explained by the affinity which carbonate of lime, oxide of iron, and alumina, which occur in every fertile soil, possess for phosphoric acid.

In the absorption of potash and ammonia, I am of opinion that the hydrated oxides of iron and alumina in the soil have a great share. Like all bases of the formula $R_2 O_3$, these oxides in a hydrated condition, in relation to strong alkalies, are weak acids, in consequence of which they have a tendency to unite with potash or ammonia under favourable circumstances.

The absorption of ammonia, potash, and of phosphoric acid by soils accords with well-known chemical facts; and as these substances are by far the most important fertilizing agents, it may be maintained that the principal absorptive properties of soils are due to chemical and not to purely physical causes.

The mechanical or physical condition of soils, however, affects very materially their productive powers; and it is only in a soil in a proper physical condition that the chemical properties can properly manifest themselves.

Great stress is laid by Liebig, as it is indeed by all good farmers, on the mechanical cultivation of the land. Liebig directs special attention to the physical state of combination, as he calls it, in which the mineral matters must exist in the surface soil, in order that they may be of utility to the plant. Whatever may be the precise meaning of the term "physical state of combination," or whether we assume that mineral food must be presented to plants in solution, or in some other mysterious form variously represented in Liebig's "Laws of Husbandry," certainly mineral food cannot be of any service to plants except it be present in the surface soil in an available form. The word "available," perhaps conveys as correct a meaning as the more novel and less graphic expression, 'physical state of combination."

In such an available condition mineral food cannot be brought into the surface soil, unless water can freely percolate through the land. This is effected by various mechanical means, such as subsoiling, trench-ploughing, surface stirring, &c. By all these means the porosity, and with it its capillary attraction, is improved. As soon as continued dry and warmer weather sets in and vegetation makes a fresh start, the mineral food prepared previously in the lower strata of the soil begins to move in an upward direction. With the evaporation of moisture from the surface, fresh food is conveyed into the surface soil by capillary attraction, and thus the fertility of the latter is again restored. The appearance of nitre, and similar saline efflorescences on the surface of soils during long-continued dry weather, sufficiently shows the display of capillary attraction.

This explains why the exhausted surface of land, abounding at a greater depth in mineral riches, remains unproductive when it rests on an impervious undrained subsoil; why winter-fallow does not materially restore the fertility of the surface if it is not accompanied by repeated ploughings, subsoiling, and similar mechanical operations, tending to increase its porosity; and why in a well-cultivated clay-soil vegetation is most luxuriant when the intervals between wet and dry weather are neither too short nor too prolonged,

Looking at the different soils of England, we meet with two extremes,—naturally barren sands and rich fertile clays, Between these two extremes we find all gradations; some partaking more of the characters of the one class, and others more of the properties of rich clay land.

Many originally barren soils, by dint of abundant manuring, the cultivation of green crops, which are consumed on the land by fattening sheep, by the purchase of oil-cakes and other kinds of concentrated food, and the increased production of home-made manure, have been brought into a high state of cultivation. But although in this improved condition they yield large crops of wheat, barley, and roots, it can hardly be said that their permanent fertility has been materially increased. Left to themselves, they soon again become unproductive, and therefore require constantly a renewal of those constituents which are removed in the crops grown on such land, High farming, in reference to light sandy soils, restores to the land infinitely more mineral matter of the most valuable kind than is removed in the corn-crops sold off the farm. As regards such land, high farming cannot therefore be called a system of robbery,

Deep, rich clay-soils, on the other hand, often contain, practically speaking, an inexhaustible supply of potash, phosphoric acid, magnesia, soluble silica, &c. The amount of mineral matter taken from such land by a long succession of the most exhausting crops is quite insignificant in comparison to that existing in twelve or eighteen inches of soil.

The actual state of fertility of land, however. does not so much depend upon the absolute amount of mineral plant-food in a given depth of soil, as upon the proportion which exists in the surface in an available condition, or as Liebig calls it a "physical state ef combination."

Mechanical cultivation, the judicious use of ammoniacal manures, the restoration of particular mineral matters which, like phosphoric acid, are most speedily removed from the surface and alternate cropping, are some of the means of repairing the fertility of the surface.

On light sandy soils, deficient in potash, phosphoric acid, and other mineral matters, ammoniacal salts or nitrate of soda should be avoided; but on soils abounding in mineral food, such dressings may be used with great advantage.

Ammoniacal salts certainly increase the solubility of mineral matters and promote their diffusion in the soil. Still, making all allowance for this they appear to have a special effect on some crops and not on others. Thus cereals are improved by them, but not clover or beans. In a series of most valuable experiments by Messrs. Lawes and Gilbert, the plots continually manured with mineral matters produced only a slightly increased crop of wheat, nor was the produce increased to any extent in those years in which mineral manures were put on the land every alternate year; whereas in the years in which ammoniacal salts were applied alternately one year and mineral matters the following, a very great increase in the wheat crop was obtained, which was likewise the case when ammoniacal salts were continuously used year after year.

With regard to the relative importance of the various fertilizing matters, it may be stated that ammonia or nitrates unquestionably are most useful substances, which the intelligent farmer may turn into profitable account, and the unreasoning one often abuses in a high degree.

But as the atmospheric as well as the rain invariably contain both ammonia and nitric acid, and as all cultivated soils contain both ready-formed ammonia and nitrogenised organic matters, which on gradual decomposition furnish ammonia or nitric acid or both, the application to the soil of nitrates or ammoniacal salts is not of the same essential primary importance as that of those mineral matters in which the land is deficient. Magnesia, lime, silica, sulphuric acid, chloride of sodium, and even potash, are either present in most soils in great abundance, or if deficient in particular soils, may be economically incorporated with them in the shape of marl, burnt clay, or gypsum, by the consumption of purchased food on the land. All these mineral matters have much less value than phosphoric acid, which is but sparingly distributed in most soils, and is largely required by all plants. Accordingly the removal of phosphoric acid from the land leads more rapidly to partial exhaustion, especially of naturally poor soils, than the removal of any other ash-constituent. Fortunately modern science and commercial enterprise have brought to light the fact, that large deposits of phosphatic materials occur far more abundantly in various parts of the world. than was supposed not many years ago.

[Of the phosphatic materials actually used in England for the manufacture of artificial manures, the following were exhibited:—South American bone-ash; Cambridgeshire and Suffolk coprolites; apatite from Norway; phosphorite from Estremadura; Sombrero, or rock guano, and phosphatic crusts, from Monk's Island, Jarvis Island, Baker Island, and various other small islets in the Carribæn Sea.]

Should the supply of Peruvian guano come to an end, which it will before many years, English agriculturists will still continue to reap the benefits which commercial enterprise, manufacturing skill and capital, more extended agricultural knowledge, steam-power applied to the cultivation of the land, intelligent labour and applied science have already conferred upon this highly-favoured country.

Conclusive proofs can be given, showing that so far from being in a progressive

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state of exhaustion, the productiveness of the soils of England has wonderfully increased during the last fifty years; and that the deporable but hitherto unavoidable loss which the sanitary laws of a civilised country necessitate, is perfectly insignificant in comparison with the immense amount of mineral riches in the great majority of soils, and with the abundant restoration of fertilizing matters to naturally poor land.

INSTITUTION OF CIVIL ENGINEERS.

THE CHARING CROSS BRIDGE.

By Mr. Harrison Hayter, M. Inst. C.E.

It was stated that this bridge consisted of nine spans,—six of 154ft. and three of 100ft.,—the centre opening of the Hungerford Suspension Bridge having been divided into four spans each of 154ft., that on the Surrey side into two spans also of spans also of 154ft. each, and the opening on the Middlesex side into three spans each of 100 feet—the superstructure over the latter being fan-shaped. The width of the river, at the site of the bridge, was 1350feet. The greatest depth of water between the two brick piers of the original bridge was 13ft. below low-water spring tides, and the average depth was about 9ft.; the rise of spring tides being 17½ft. The level of the rails was 31ft. above Trinity high-water mark, and there was a clear minimum headway under the bridge of 25ft. above the same datum.

The superstructure was carried by cylinders sunk into the bed of the river and by the piers and abutments of the suspension bridge, the abutments having been considerably lengthened. The cylinders, excepting at the fan end were, 14ft. diameter below the surface of the ground, and 10ft. diameter above, the junction between the two sizes being effected by a conical length. There were four piers formed of these cylinders, each consisting of two cylinders, 49ft. 4in. apart from centre to centre. They were of cast iron, 1¼in. in thickness throughout, and the circumference was divided into segments, with interior flanges round all the edges, through which the segments were bolted together; and a horizontal interior rib was also cast in the middle of each segment. There were thus continuous vertical lines of ribs, securing a strong columnar arrangement.

The strata through which the cylinders were sunk consisted of mud and gravel, of varying thicknesses, overlying the London clay. The sinking was effected by excavating the material from the inside—at first by divers, but after the London clay was reached and the water was pumped out, in the ordinary way—and by weighting the cylinders, to an average load of 150 tons each. These cylinders were sunk to depths of 52ft., 62ft., and in one case to 72ft. below Trinity high-water mark. They were filled with Portland cement concrete up to where the conical length commenced, and above with brickwork, set in Portland cement mortar, to the underside of the granite bearing blocks, which were 2ft. 6in. in thickness, and projected 1in. above the top of the cylinders, in order that the weight might not come on the upper edge of the ironwork. With a view of testing the strength of the foundations, the two cylinders in the pier nearest to the Surrey side, after being completed up to the level of high-water and filled with concrete and brickwork, were each weighted with 700 tons, being about equal to the greatest load they could possibly have to sustain, supposing the four lines of rails on the bridge to be loaded with locomotive engines. This caused the cylinders to sink permanently 4in. To bring the other cylinders to a bearing, so as to prevent any settlement after the completion of the bridge, from the weight of the permanent and moving loads, they were each weighted with 450 tons, when it was found that they permanently sank, on an average, 3in. each. Each pair of cylinders forming a pier was connected together transversely by a wrought-iron box girder, 4ft. deep, which also served as a cross-girder for supporting the roadway. Assuming the four lines of way on the bridge to be loaded with locomotive engines, the pressure on the base of the cylinders would amount to 8 tons per square foot, and on the brickwork at the top of the cone to about 9 tons per square foot.

The superstructure of each of the 154ft. openings consisted of two main girders, to the underside of which were suspended cross-girders, for carrying the roadway platform. These cross-girders extended beyond the main girders, and formed a series of cantilevers on the outer sides, for supporting two footpaths, each 7ft. wide in the clear. The main girders were of wrought-iron, and were not continuous, but extended only over one opening. Each girder had to support, inclusive of its own weight, a maximum distributed load of 750 tons. The extreme depth of these girders was 14ft., and the depth between the centres of gravity of the top and bottom members was 12ft. 9in. The sides of the girders between the bearings were divided into fourteen equal parts by a pair of vertical bars, connected to the top and bottom by pins of puddled steel, 7in. diameter at the ends of the girder, decreasing to 5in. diameter at the centre; and each division contained a double set of two diagonals crossing each other. The top and the bottom of these girders were of boiler-plate, and consisted of horizontal tables 4ft. and 3ft. wide respectively, and of four vertical ribs, the two outer rows being 24in. deep, and the two inner rows 21in. deep. The aggregate thickness of the plates in the horizontal table of the top in the centre of the girder was 3⅛in. and in the bottom 3⅛ without the angle irons, and of 4⅛in. and 4⅛in. respectively with the angle-irons, but exclusive of the angle-iron covers. It was arranged that, with the greatest load, the maximum strains should not exceed 4 tons per square inch in compression, and 5 tons per square inch in extension. All the rivet-holes were drilled by machines capable of drilling several holes at one time. This plan was, under the circumstances, less costly than punching, besides which a great saving was effected in putting the work together. The diagonals acting as ties were of Howard's rolled suspension links, each separate tie being composed of two or three links, as required, rivetted together. The diagonals acting as struts were each in one solid forging, and were united together in pairs by zigzag bracing of wrought iron. In the centre of the girder, where the diagonals acted as both struts and ties, the pairs were united together in the two central spaces by the zigzag work. The dimensions of the struts varied from 12in. by 3in. at the ends to 6in., by 2½in. in the middle, and of the ties from 12in. by 2⅛in. at the ends to 6in., by 2in. in the middle. The ends of the girders over the piers were boxed in, with plates ⅜in. thick, stiffened by angle and T irons. Over the cylinders the girders rested on sheet lead, laid upon the granite blocks. On the brick piers and the Surrey abutment, they rested upon roller bed-plates. The girders were put together in place on a staging, the upper and lower platforms of which were accurately adjusted to the proper camber. The whole of the plates were drilled, and the struts and ties were completed, before being sent to the works. The weight of each main girder was 190 tons. One of the main girders was tested when in its place with a distributed load of 400 tons, when the greatest deflection observed was 1,⅝in., and the permanent deflection after the load was removed was ⅛in.

The cross girders of the 154ft. openings were of wrought iron, and were generally similar in character to the main girders, from which they were suspended, at intervals of 11ft. apart, from centre to centre. They were 4ft. deep in the middle, and 2ft. 1⅛in. deep where the cantilevers were united to them outside the main girders. The top and bottom consisted of two plates, 18in. wide by ⅜in. thick, the sides being of lattice bars united to the top and bottom by angle irons. The cantilevers decreased from 2ft. 1⅛in. deep at their junction with the cross girders to 1ft. 2in. deep at their extremities. Each cross-girder, including the two cantilevers, weighed 9 tons. When two of these cross girders, without the cantilevers, were tested with a load of 140 tons, equivalent to 70 tons on each girder, the maximum deflection in the centre was 1in., and the permanent deflection when the load was removed was ⅛in.

The superstructure of the three 100ft. openings of the fan end was supported by the brick pier and abutment on the Middlesex side of the suspension bridge, and intermediate to these by two rows of seven and of nine cast iron cylinders respectively. These cylinders were 10ft. diameter below the ground level, the outer ones being 8ft. diameter, and the inner ones 6ft. diameteter above that level. They were sunk to depths averaging 40ft below Trinity high-water mark, and were filled with Portland cement concrete to about 5ft. above that level; but it was not considered necessary to fill in the remaining portion of these cylinders. On account of the great width of the fan end, which increased from 49ft. 4in. at the brick pier to 168ft. at the abutment, the plan of supporting the roadway on cross girders, suspended from outside main girders, was inadmissible; and as it was not desirable to introduce intermediate main girders, projecting above the line of rails, the roadway was carried by interior plate girders, laid at right angles by the piers and abutments, and by the outside main girders, which were laid at the angle of inclination of the fan. The outside main girders were of the same depth, and were generally of the same character, although lighter in all parts, and were fixed at the same level, as the girders of the 154ft. openings. The interior plate girders were of the ordinary construction, 5ft. deep, or one-twentieth of the span, and weighed 26 tons each. The triangular spaces between the outside main girders and the outer interior plate girders were filled in with cross-girders, terminated by cantilevers, projecting beyond the face girders, and similar to those outside the main girders of the 154ft. openings.

The roadway platform over the 154ft. openings consisted of planking 4in. thick, spiked to longitudinal timbers, 15in. by 15in., placed underneath the rails, and bolted to the cross girders. Over the fan end, the platform consisted of planking 6in. thick, secured to the girders. The footpath platforms were of planking 6in. thick.

The first cylinder of the Charing Cross bridge was pitched on the 6th of June, 1860, and as the bridge was now on the eve of completion, its construction would thus extend over a period of about three years. The weight of wrought iron in the bridge, including the steel pins, was 4950 tons, and of cast iron, 1950 tons. The total cost, including the abutments, would be £180,000, or £1 15s. per square foot, and £131 per lineal foot. The cylinders of the 154ft. openings cost complete £20 per lineal foot; the outer cylinders of the piers of the fan end cost about £12, and the inner ones about £10 per lineal foot. The bridge was designed by Mr. Hawkshaw (President Inst. C.E.), the engineer to the Charing Cross Railway Company; and was carried out under his immediate supervision, Mr. John H. Stanton (M. Inst. C.E.) being the resident engineer. Mr. George Wythes was the contractor for the construction of the railway, but this bridge was sublet to Messrs. Cochrane & Co., whose representative on the works was Mr. Joseph Phillips (Assoc. Inst. C.E.)

DESCRIPTION OF THE LYDGATE AND OF THE BUCKHORN WESTON RAILWAY TUNNELS,

By Mr. J. G. Fraser, M. Inst. C.E.

It was assumed that the aggregate length of the tunnels now daily traversed by railway trains in the United Kingdom amounted to 80 miles; and supposing their cost to have been on an average £45 per lineal yard, their construction must have caused the expenditure of six and a half millions sterling. Up to the present time this interesting branch of Civil Engineering had not been much discussed at the Institution; as the Minutes of Proceedings only contained accounts of a total length of about 3 miles, involving an outlay of about one quarter of a million sterling. Each tunnel had its own history, and its construction demanded peculiar treatment, according to the character of the strata, the springs of water, etc. If particulars of these works were transmitted to the Institution from time to time more effectual measures might in many cases be practised, with advantage to public economy.

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The tunnels forming the subject of this communication were both executed under the immediate superintendence of the Author, as Resident Engineer for Messrs. Locke and Errington, the Engineers-in-chief.

The Lydgate Tunnel, on the Oldham branch of the London and North Western Railway, was driven through the coal measures. A longitudinal section which accompanied the Paper, prepared from actual measurements taken during the progress of the works, illustrated the geological details. Faults were common in this formation: sometimes severing it in the line of the dip, and at others in the line of the bearing. Several distortions were encountered, and at one point, one-half of the tunnel was in strong shale and rock, and the other half in wet and loose shale. The total length of the tunnel was 1332 lineal yards; of this about 1046 yards were on a straight line, and 286 yards on a curve of 74 chains radius; its width was 25ft. at the level of the rails, with a height of 20ft. Four permanent shafts, each 9ft, in diameter in the clear, were sunk at intervals of about 230yds., of the respective depths of 53½, 80, 75¾, and 53 yards, They were lined with 9in. brickwork, or with 12 inches of masonry, except in the rock. An old colliery shaft, which had been closed for many years, was also re-opened, and a cross-heading was driven from it into the tunnel, a distance of 13½ yards. When foul air was met with, a supply of fresh air was forced into the workings by means of fans, until a junction was effected between the headings. There was a considerable amount of choke-damp in the neighbourhood of the old coal workings. To overcome its effects, a bore-hole was sunk from the surface, which was lined with an iron pipe, and through this fresh air was forced into the tunnel. The sinking of the shafts was carried on in the usual manner. by excavating through soft material, and by blasting and drilling through rock. The average rate of progress was 11 lineal yards per month. After attaining a depth of 20 yards, the material was raised by engine power.

A bottom heading was driven from the faces worked from the cuttings at each end; but with these exceptions the tunnel was mined by a top heading, 6½ft. by 4½ft. first being made for the full distance of each length. The crown was protected by larch bars and poling boards, and after the ground was secured, it was gradually widened out to the shape of the tunnel, the same description of timbering being continued to about 10ft. above the formation level. The contract price for the excavation, including the timbering. was 4*s.* 6*d.* per cubic yard. In the construction of a tunnel, the masons, or bricklayers, should, as a rule, commence the lining as soon as possible after the ground was prepared for them by the miners. The lengths mined at each face varied according to the nature of the ground; averaging in loose shale, 3 lineal yards, through stony shale 5 yards, and through rock 8 yards, or in some instances 10 yards. The prices paid to the miners ranged from £8 to £18 per lineal yard, one half of the total length amounting to £12, or less.

The centres used were skeleton ribs, set about 1¼ yard apart; but at the leading ends two ribs were fixed close together. This description of centering was found to answer very well. The price allowed for setting each rib was 8*s.* The masonry of the side walls was of coursed rubble. The arch for a length of 332 lineal yards was turned with fitted rubble, but owing to the scarcity of good bedded stone, the remaining length was built of brickwork. The average quantity of masonry per lineal yard was 12⅓ cubic yards, and the contract price throughout was 20*s.* per cubic yard. The mortar was composed of Barrow stone lime mixed with coal-ashes, in the proportion of 2 to 1, ground by heavy iron rollers, and used fresh. Its setting properties were most satisfactory. The spaces between the crown bars, called the mid-feather, were filled up with brickwork, and the bars themselves were left in where they had "sagged."

The first length of the tunnel was keyed in on the 27th of October, 1854, and the last was finished on the 21st of March, 1856, a period of seventeen months, or equivalent to about 80 lineal yards completed per month, exclusive of the sinking of the shafts. The contract price for the tunnel was £26 per lineal yard through rock, and £35 16*s.* per lineal yard through shale, the average price being £30 per lineal yard.

The Buckhorn Weston Tunnel, on the Salisbury and Yeovil Railway, was 397 lineal yards in length, 25ft. in extreme width, and 20 feet in height above the level of the rails. It was constructed through Kimmeridge clay, intersected with veins of loose rock. These veins acted as conduits for a large body of water, amounting to about 90 gallons per minute, which flowed in at the crown of the tunnel for nearly one-half its length. To remedy the evil effects arising from this volume of water, a heading, 5ft. by 5ft., was driven above the tunnel, and about 10 yards on the upper side of it, for a length of 200 yards. A pipe 12 inches diameter, was laid in this heading, and the remainder of the space was filled in with loose stone. The water was thus intercepted, and conveyed away from the work. It was originally intended to execute this tunnel by means of a bottom heading, sufficiently large for ordinary waggons, from the cutting at the west end, and to sink two shafts. After the heading had been driven for a length of 200 lineal yards, it was found that the action of the atmosphere caused the sides to bulge in so much that this plan had to be abandoned. A smaller heading was then substituted, and three additional shafts had in consequence to be sunk. The shafts, which were only temporary, were 8ft. square, and were lined with timber. Their cost amounted to £1 10*s.* per lineal yard of tunnel.

The mining was performed in a similar way to that of the Lydgate Tunnel; a top heading being first driven for each shaft. The average price for mining and tipping was 4*s.* 6*d.* per cubic yard, and the quantity amounted to 80 cubic yards per lineal yard of tunnel. The lengths mined at each face ranged from 3½ lineal yards in heavy ground, to 5 lineal yards in favourable strata. The average cost of mining was £30 per lineal yard, exclusive of the shafts. The crown bars were of larch, 18in. diameter, and were fixed about 18in. apart.

The centres were strongly braced, and were placed about 1½ yard apart. Each rib contained 35 cubic feet of timber, and 285 lbs. of wrought iron in bolts and straps, and the cost of setting amounted to 6*s.* per lineal yard of the tunnel. As side pressure was anticipated at the commencement of the work, the first ten lengths were built with an invert, which contained 4 cubic yards of brickwork, per lineal yard. Further experience showed, however, that this was not necessary. The tunnel was built throughout of brickwork, upwards of six millions of bricks being used, and the average quantity per lineal yard of tunnel was 20 cubic yards. For a length of 390 lineal yards, where the water occurred, the work was 2ft. 8in. in thickness. The spaces behind the brickwork were filled in solid, and throughout the heavy ground three bars were left in, on an average in each length. As there was no sharp sand in the neighbourhood, burnt clay, fine sand, and broken bricks were ground together, and mixed with Bridgewater hydraulic lime, in the proportions of 2 to 1; the result was perfectly satisfactory.

The first length of this tunnel was keyed in on the 6th of October, 1858, and the last was completed on the 17th of February, 1860, a period of sixteen months. The total cost had amounted to £53,000, or £72 per lineal yard; detailed particulars being given of the cost of the different items.

PUBLIC WORKS IN PERNAMBUCO, IN THE EMPIRE OF BRAZIL.

By Mr. W. M. Peninston, M. Inst. C.E.

It was stated that the object of this paper was to describe a few of the public works of one of the most extensive, productive, and least-known empires of the world. Pernambuco was one of the principal, but by no means the largest, of the twenty provinces of which the empire consisted. It had an area about equal to England, whilst its population was estimated not to exceed one million. The commercial capital was built on a low, sandy flat, but little raised above the level of the ocean, and surrounded by an amphitheatre of hills. Its position was selected on account of the natural harbour formed there by a reef, or in Portuguese, Recife, the true name of the city. This reef ran for hundreds of leagues parallel to, and only a short distance from, the coast. In the neighbourhood of Recife, it was composed of soft, calcareous, and silicious sandstone, intermixed with shells of existing species. In consequence of the absence of quays with sufficient depth of water for vessels to come alongside, all cargoes had to be shipped and discharged by means of lighters.

After alluding to the amount of shipping frequenting the port, the character and extent of the exports and imports, the currency, and the weights and measures, reference was made to the climate of Pernambuco; and it was stated that in the city, which was less healthy than the country, with a population of 120,000, until lately without any drainage, and with a consumption of about ¾ of a gallon of water per head per diem, the death rate was only 1¾ per cent., per annum. The variations in the temperature were considerably less, and the regularity of any hour was much greater, than in this country. Thus, in the summer the temperature did not vary more than 1° above or below 82° at 9 a.m. in the shade, nor in the winter 2° above or below 78° at the same time. The rainfall in 1860 was 67·20in., in 1861 it amounted to 123·75in., and for the first six months in 1862 it was 53·64in. The extreme recorded rainfall during this period occurred in January, 1861, when it amounted to 7¼in. in twenty-four hours, of which upwards of 4in. fell in six hours. The highest floods in the valleys crossed by the Recife and Sao Francisco railway varied from 15 to 25ft.; but these rose very rapidly, as frequently the river was in its usual quiescent state in the evening, and in the morning it was a raging torrent.

The waterworks and the gas works in the capital were then briefly noticed, after which the streets and street transport came under review, including the Government roads and bridges. The principal streets of the city, which were extremely narrow, were pitched, or very roughly paved, with broken granite, brought from Europe as ships' ballast. Outside the town, the total length of road passable during the greater part of the year for wheeled carriages throughout the province was about 130 miles. Of this one-sixth only was metalled. In some districts the roads were practically useless, from the want of bridges across the rivers; in others timber bridges had been built, but on the new roads now being made under the direction of Mr. W. Martineau (M. Inst. C.E.), the Government engineer, iron bridges had been adopted. The cost of the roads had been in times past, almost fabulous, exceeding that of European railways. But according to the latest contracts, the cost was under £3000 a mile, including the bridges, but exclusive of the metalling, the price of which a short time back amounted to upwards of £1 per cubic yard, when broken and spread in place. The bullock tracks were scarcely available for public traffic, which was at present chiefly carried on by pack-horses, on tracks barely wide enough for two horses to pass each other, and pursuing a most devious course.

There was properly no river navigation in Pernambuco; but the Sao Francisco, which rose in the hills in the rich mining district at the back of Rio Janeiro, flowed northward from Minas Geras, till it entered the province at its south-west angle. It there precipitated itself over the Falls of Paulo Affonco, a depth of nearly 200ft., whence it took its course through a rocky rapid channel for nearly 200 miles to the sea. Above these falls the river was navigable to the Falls of Pira Pora, a distance of from 600 to 800 miles, and it was to this as a feeder that the railways from Recife and Bahia were both directed.

The absence of river navigation, the inefficiency and great cost of public roads, and the horrible character of the common roads of the country, naturally led to the consideration of a railway. This was brought forward by Messrs. de Mornay, who proposed to carry a line throughout the entire length of the province from Recife, the capital, to the Falls of Paulo Affonco, on the Rio Sao Francisco. A concession was granted with a guarantee of 5 per cent. from the Imperial Government, and of 2 per cent, from the Provincial Government, upon the estimated cost of completing the first portion of the line from Recife to the River Una, a distance of about 75 miles. The original estimate was for a line on the North American system at £540,100, but considerable alterations and improvements had caused the capital to be increased to £1,200,000, to which amount the guarantee

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was extended; but as this last has not been sufficient to complete the line, the Government had now agreed to a further extension of the capital, to cover the sum actually expended on the works.

The country traversed by the first portion of the Recife and Sao Francisco Railway to the River Una, presented a great uniformity of its physical features. It consisted of a succession of narrow valleys, with hills from 100 to 150ft. in height, composed almost without exception of a rock of a granitic character, varying from a state of perfect decomposition to its natural hardness, the proportion of soft ground to hard rock being at least 10 to 1. It was decided that the curves should not be sharper than 20 chains radius, or the gradients steeper than 1 in 80, nor longer at that inclination than 2 miles. In no case had the specified gradient approached the limited length, and in two cases only had it exceeded 1 mile in length. There was only one tunnel, and that under 500ft. in length. The earthwork on the heaviest part of the line averaged for about 20 miles, 40,000 cubic yards, per mile—which was double that on the other sections—the highest embankment and the deepest cutting being 40ft. The width of the cuttings at the formation level was 20ft., reduced to 10ft. in rock. The width of the embankments at the same level was 16ft., their height being fixed at 18in. above the highest known floods. There were eight principal bridges, all of iron, varying in height from 15 to 25ft., and numbering together two spans of 90ft., two of 80ft., eighteen of 60ft., and one of 50ft. The permanent way consisted of the ordinary double-headed rail, laid on creosoted larch cross sleepers; but 10 miles of the line had been laid, as an experiment, with Greave's "pot" sleepers. Trials were being made of native timber for sleepers as well as for keys, and samples of upwards of one hundred kinds of timber were exhibited, most of which were easily obtainable within a short distance of the railway, and would be available for temporary purposes, but probably not more than a dozen or twenty would be useful for any permanent work.

The stations and station arrangements, the rolling stock, the engine and carriage sheds, and the workshops for repairs and for waggon building, were then severally described. It was stated that the works of the railway were commenced in May, 1856, and the whole of the first section to the River Una was finally opened in November, 1862. Part of the line had now been in operation for five years, and during that time there had not been an accident to a passenger, even when five engines had been at work at the same time on a length of 20 miles of single line. This was very creditable to the locomotive superintendent and engine drivers, as the responsibility rested with them, the other officials, with the exception of the traffic manager, being all natives.

The labour question was one of the most vital importance to the future of Brazil. Agricultural operations had heretofore been conducted exclusively by slaves, as also, mainly, the work of porters and lightermen about the ships, harbour, and warehouses of Recife, for some years past, however, the laws against the further importation of slaves had been strictly enforced, so that their number had gradually decreased. Liberal concessions had been granted from time time by the Government for the promotion of colonisation, but with no commensurate success. Experience had proved that, both in the province of Pernambuco and in the adjoining province, there was an ample supply of manual labour for any public works, or extension of agricultural operations, at present probable. But the difficulty was to persuade the native Brazilians that it was to their advantage to seek employment. The only work that the native was accustomed to was ditching, and the only tool, the hoe. The first lesson was to induce a native to give up the hoe, and take to the pick and shovel. Want of order and discipline prevented them from working a barrow road properly, and from tipping a waggon; but a light hand-cart they worked very well, and they would fill a set of ballast waggons in less time than might be expected, at a cost of 9*d.* to 10½*d.* per cubic yard, exclusive of road-laying and repairs. Men's wages varied from 3*s.* to 3*s.* 9*d.* per day, the latter pay being for picked men in all cases.

Although the difficulties were great in getting the native labourer into order, temper and perseverance would overcome them with time: but with the native artizans the difficulties were greater still, as there were so few mechanics in the principal towns, scarcely sufficient for the ordinary work, that they were even more independent than the common labourer, and infinitely more conceited and wedded to their own ways. The native country carpenter had but one tool, the "euxo," or hand adze, and not having the slightest idea of square or line, all his work had to be set out. His wages were from 4*s.* 6*d.* to 5*s.* 9*d.* per day. Brickwork and masonry cost, for labour only, from 9*s.* to 14*s.* per cubic yard, according to the thickness and the height; the wages varying from 4*s.* 1*d.* to 6*s.* 6*d.* per day. Native smiths received 5*s.* 6*d.* to 6*s.* 9*d.*, and painters 6*s.* 9*d.* to 9*s.* per day. From the description which was given of the capabilities of the native workmen, it was believed that foreigners must be imported for all the higher orders of work.

Pernambuco produced, in common with most provinces of Brazil, very superior timber, and of infinite variety; but the difficulty of getting it, and the absence of roads and the means of transport, rendered foreign timber cheaper at the seaports, and at all places at any distance from the forests. This was also the case with regard to stone, the ashlar dressings used in the public buildings and in the best finished private houses having been sent from Lisbon. The native bricks were of the rudest description, and were used in all stages, from that of being simply sun-dried to sound kiln-burnt. In consequence of the action of the atmosphere on the native bricks, it was necessary to plaster all exposed work. The Brazilian or Portuguese tile was almost invariably used for covering roofs, and although attempts had been made to introduce corrugated iron and other materials for roofing, nothing could compare, where ventilation was so important, with the ordinary tile of the country.

The Appendix contained a list of the standard dimensions of the Recife and San Francisco Railway, and of the principal structures upon it, as well as of the rolling stock. Also, tables of the wages of the different classes of labourers and artizans, of the prices of the materials, and the cost of various kinds of work and of transport.

ON THE MANUFACTURE OF DUPLICATE MACHINES AND ENGINES.

By Mr. John Fernie, Assoc. Inst. C.E.

After referring to the block-making machinery, designed by the elder Brunel for Portsmouth Dockyard, and to the Small Arms' Factory at Enfield, as examples tending to show that the system of duplicates both cheapened and improved the manufacture of all articles to which it could be applied, the Author remarked that, until lately, little or nothing had been done in its application to the manufacturing of machines or engines on a large scale. It was true the principle had been acknowledged, and various writers had urged the desirableness of its introduction into the railway system; but with such large component parts, special machines were out of the question, and the only other possible mode was working to a correct standard.

Mr. Whitworth (M. Inst. C.E.) had advocated, in several papers read before different scientific societies, the adoption of a system of measurement for mechanical engineering work, in which the inch was to be the basis, subdivided into a thousand parts for the finer dimensions. In 1851, he exhibited a machine for obtaining fine accurate measurements by touch, and he showed, by models, that the thousandth of an inch was not only an appreciable quantity, but in many cases its difference was what constituted a bad fit.

The Author having long been satisfied that the mode of taking dimensions in the workshop was behind the times, had, with the sanction of Mr. Kirtley, the locomotive superintendent, established during the last five years, in the workshops of the Midland Railway at Derby, a system which had proved most beneficial, not only in reducing the cost of the work, but in greatly improving it; and at the same time perfecting the only plan by which all the parts of engines could become duplicates of one another. The system of end measurement and a gravity piece, as invented by Mr. Whitworth, was adopted, and a machine was constructed capable of taking in 100 inches. This machine consisted of a strong bed plate, having on the upper surface a V groove, planed throughout its whole length. At one end there was a headstock, through which a square spindle, fitting the groove, was propelled by a hand wheel, which formed the nut of a screw having ten threads to an inch. This nut was in two parts, and could be tightened up by screws, so as to prevent lateral play; and a collar and washer, also adjustable, prevented any play in the headstock. The other end of the bed had also a headstock and screw movement, so as to adjust the length of the pieces in the groove, and bring the readings of the index to O. The difference between this machine and Mr. Whitworth's was in the way the subdivisions of the inch were obtained. In the Whitworth machine a screw with exactly ten threads to an inch was first made; whereas in this machine, as a screw could not be found with exactly ten threads, it was necessary to run a thread on the face of the hand wheel, and sub-divide this for the length required for an inch. The manner of obtaining duplicates with this machine was exceedingly simple. First a perfect inch was got, and then a second was made, by means of the gravity piece; after which, all other sizes up to 100-in. were readily obtained. These sizes were now kept as duplicates. The finer dimensions were read from the divisions on the wheel, and from these, gauges for use in the workshop were made. All dimensions were thus duplicate multiples, or divisions of an inch, and a bare one-sixteenth of an inch became not an unknown quantity, variable with the rule or the eye of the workman, but so many thousandths of an inch, which were stamped on the gauges, and were soon understood. One of the first applications of the system in the workshop was to establish the necessary degree of tension required to ensure a perfect fit of a wheel on its axle, The result of experiments showed that with a difference of ·005 of an inch in the dimensions, there was a small permanent set in the wheel boss, but with a difference of ·003 of an inch the set was hardly perceptible. It was found however that, with ordinary lathe work, ·003 was rather to fine a dimension, as lathes were seldom exactly true in their spindles. The size ·005 was then finally adopted. In shrinking on outside cranks it was found that ·015 was sufficient to retain them in their places, while cross-head spindles 2½in. diameter required a difference of ·004, and levers with 3in. holes of only ·001.

The gauges were then described, as well as the manner in which the lengths of the eccentric rods were preserved uniform, and how the key groove in the outside cranks and the eccentric key grooves were cut. No setting out was required, and there was no chance of mistake from the carelessness of workmen. Unless the cranks and eccentrics were exact, they would not fit the tools, and thus a certainty was attained in the depth and position of the key groove.

Considerable improvements had been effected of late years in plate moulding, and the plan adopted at the Midland Railway Works at Derby, was believed to be the first application of the system to such large and complicated castings as locomotive cylinders. Moulding boxes for axle brasses were exhibited, and a description was given of the manner of moulding cylinders. By this mode, a minimum quantity of sand was used, the projecting pieces cast on the boxes, did away with the necessity of lifters, the castings came cleaner from the sand, the patterns were not knocked to pieces by rapping, and the cylinders were perfectly true in the bore and passages.

The plan of fitting together the various pieces, so as to ensure uniformity in erection as well as in detail was then described; and it was urged, that by this system of accurate measurement, however large the parts might be, they became duplicates of one another, and could at any time be replaced. The advantages claimed were, economy in manufacture, greater excellence in workmanship, and a perfect system of duplicates, whereby the parts became interchangeable. The author especially recommended this system to the engineers of Indian and Colonial Railways, as there was no reason why the different parts of engines and of rolling stock generally, should not be as perfect duplicates as those of the Enfield rifle.

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