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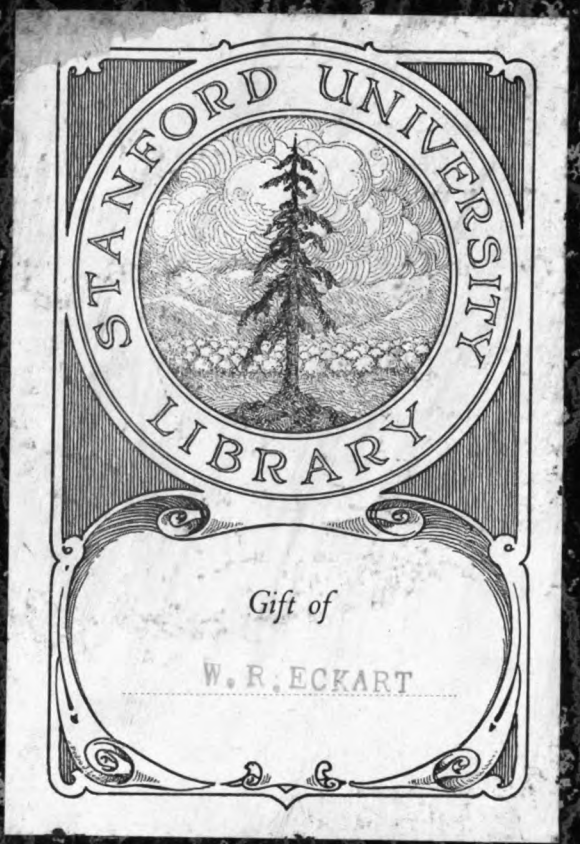
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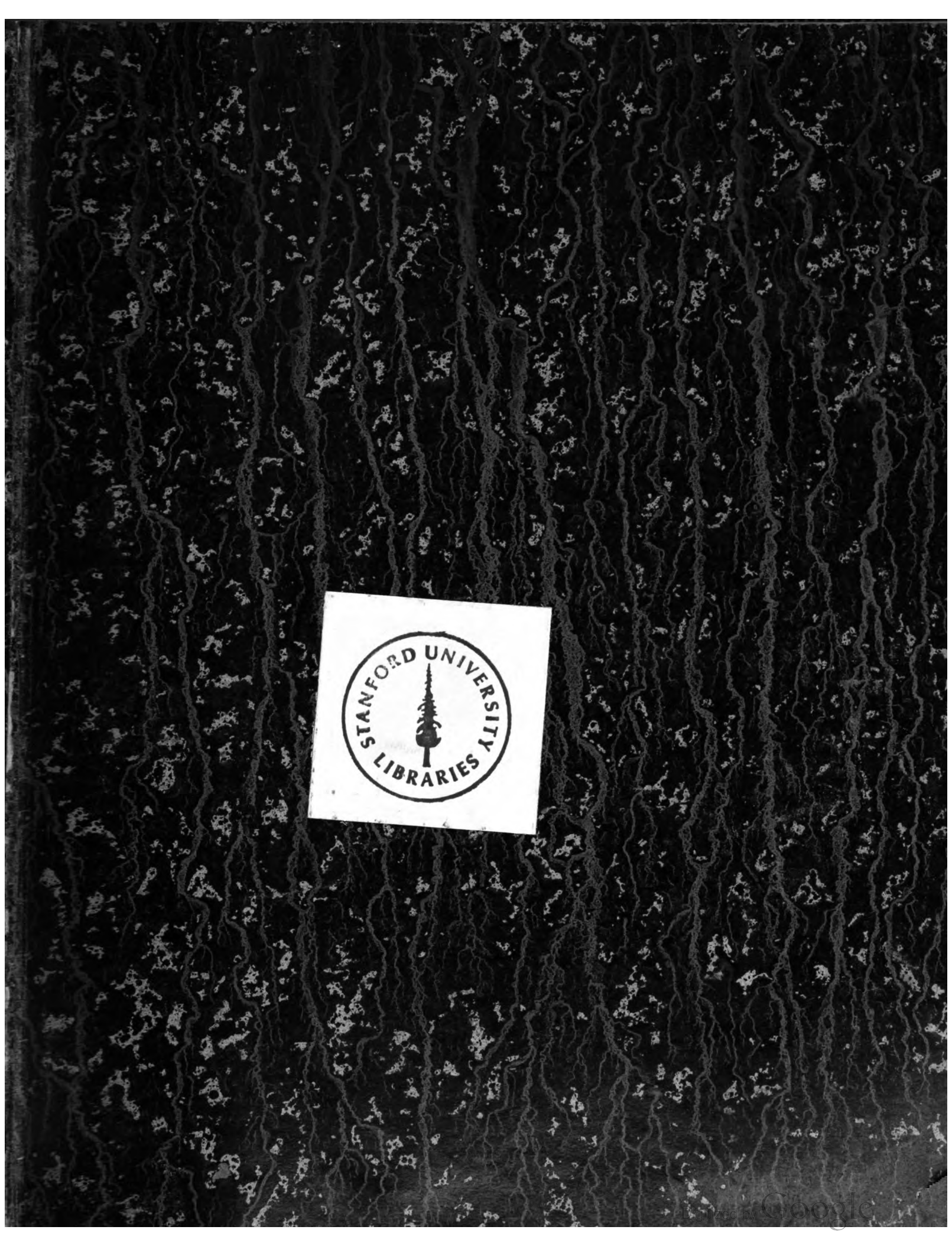

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TO THE BINDER.

Plate No. 224.—Incline tank engine for the Great Indian Peninsular Railway, Bombay, to face title-page.

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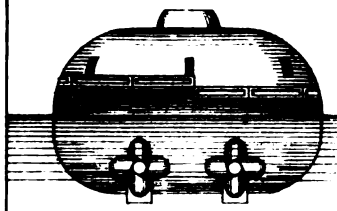
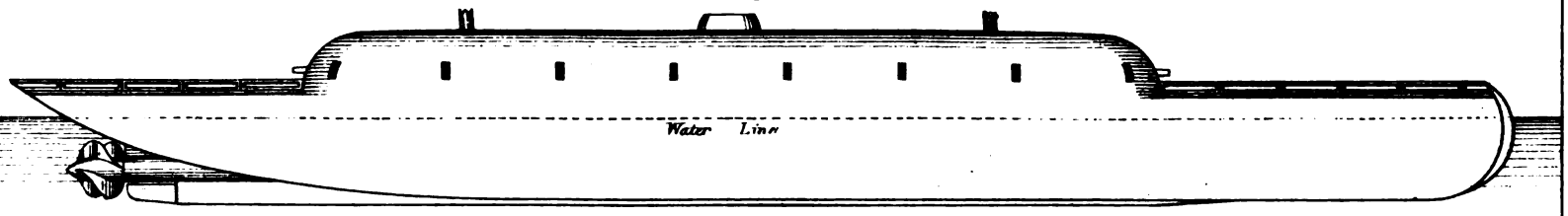
Fig. 5.



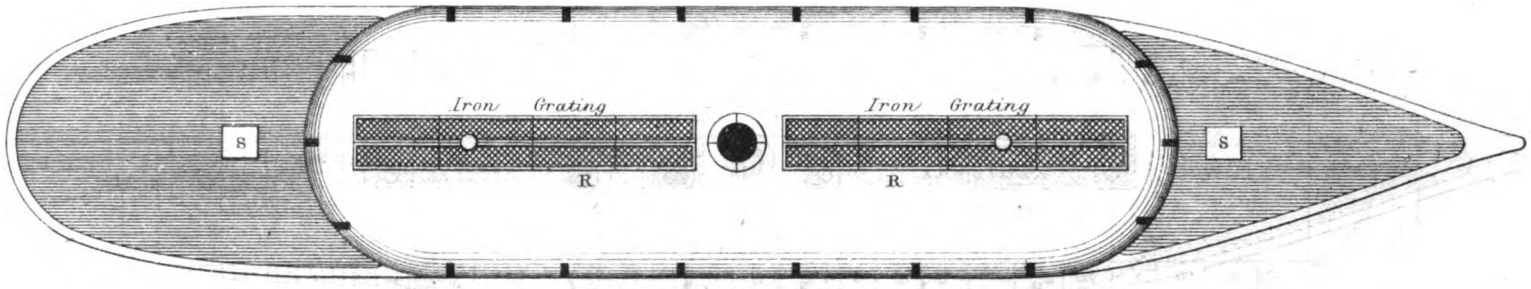
Stern View.

Fig. 1.



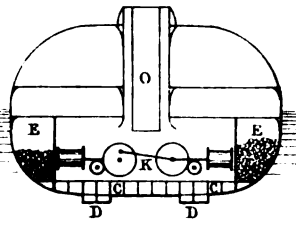
Elevation.

Fig. 2.



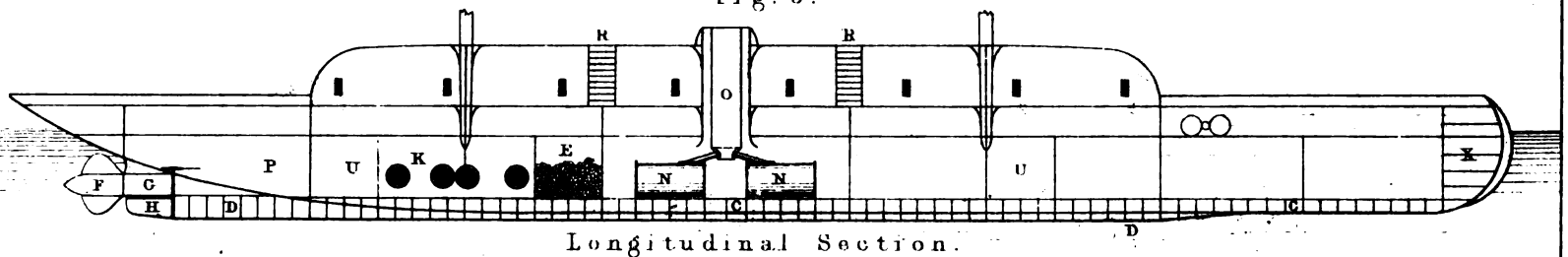
Plan of Upper Deck.

Fig. 6.



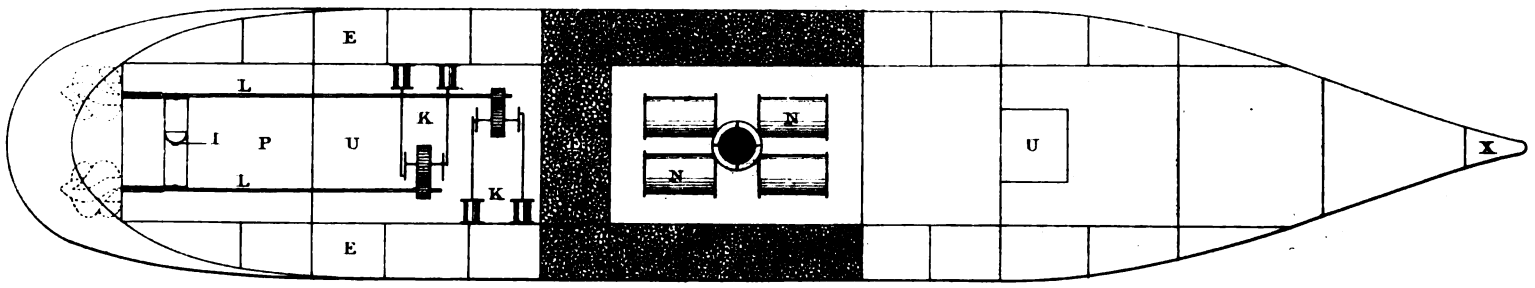
Transverse Section.

Fig. 3.

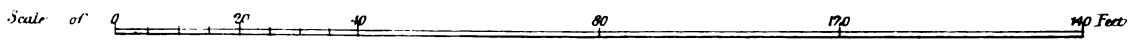


Longitudinal Section.

Fig. 4.



Floor Plan.



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PASSENGER OR TROOP SHIP.

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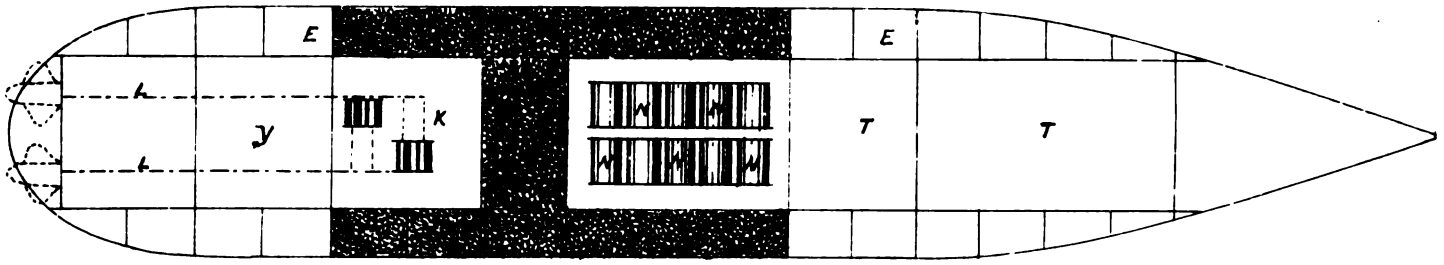
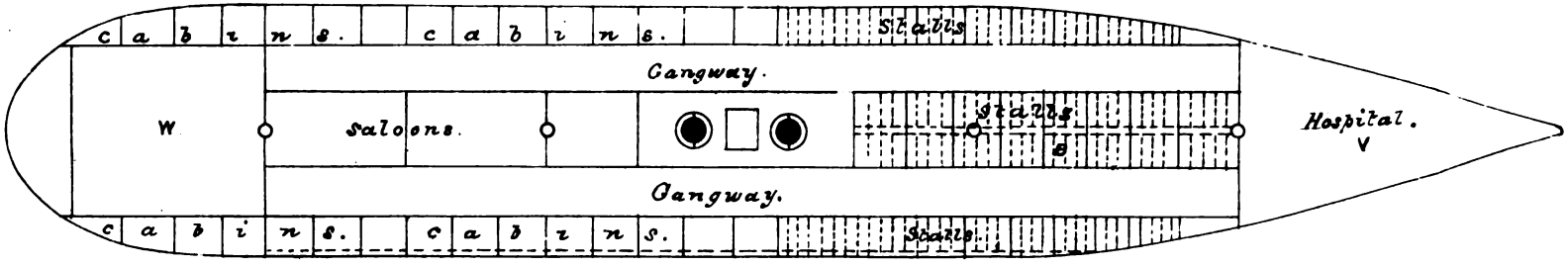


Floor Plan shewing Cellular arrangement of the Coal-Bunkers.

FIG. 2.



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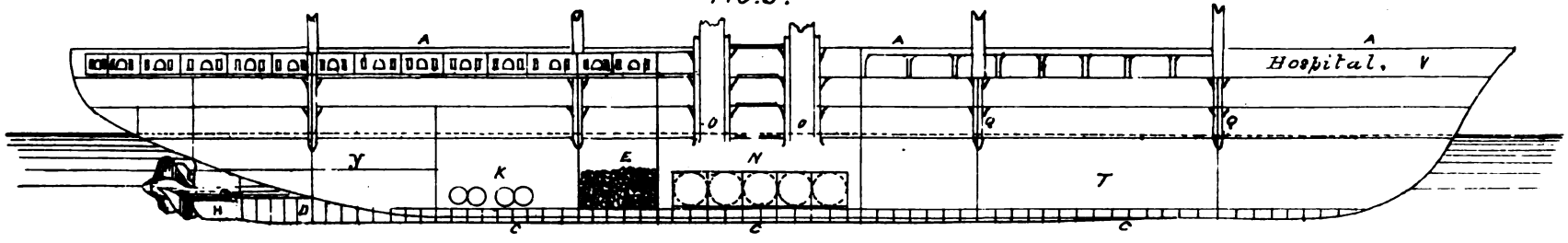
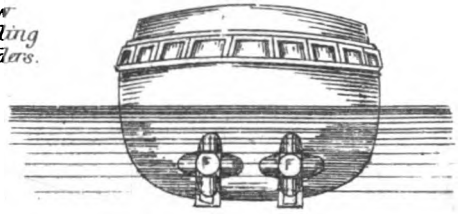


FIG. 6.

FIG. 4.

Stern View shewing non-fouling Propellers and Rudders.



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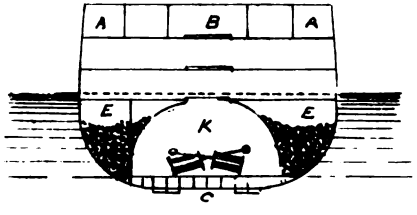

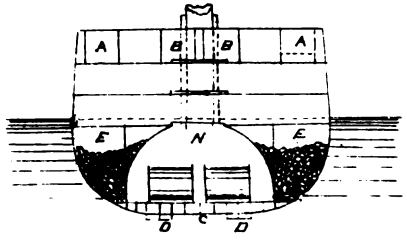

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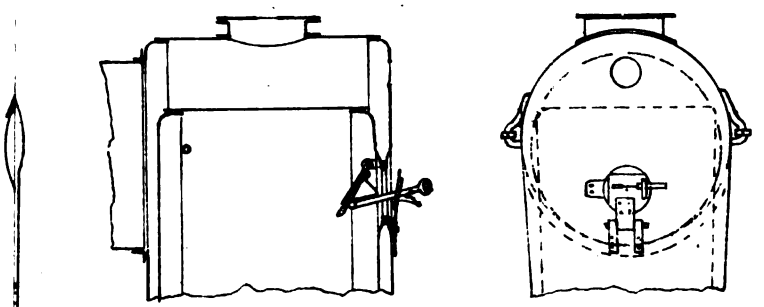
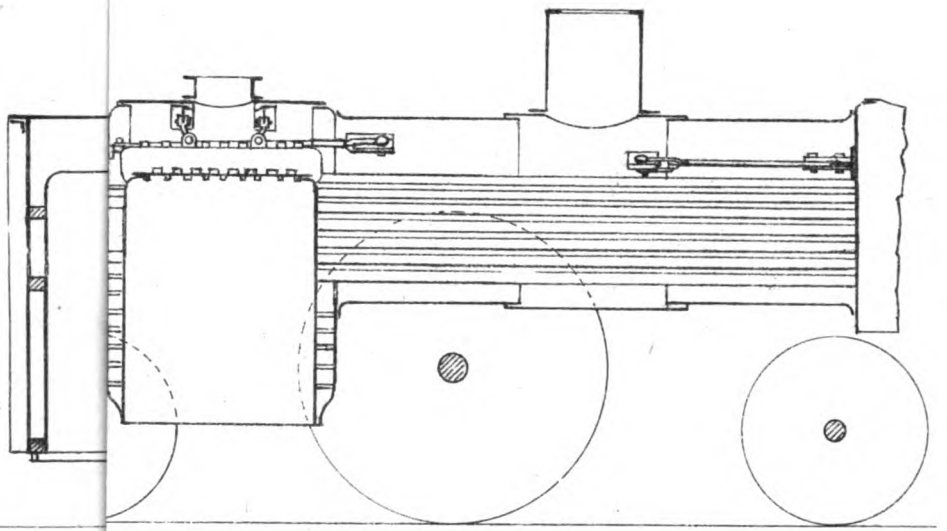
FIG. 9.





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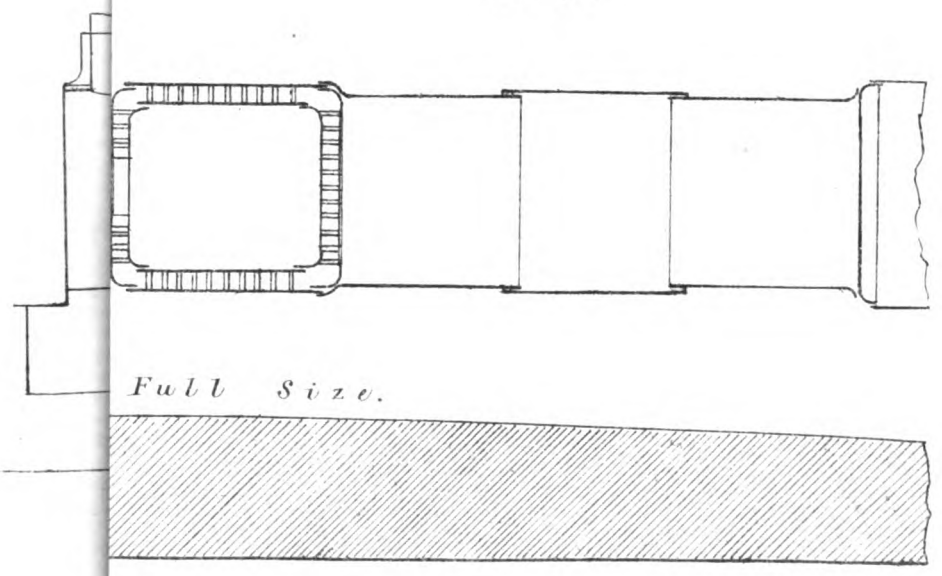

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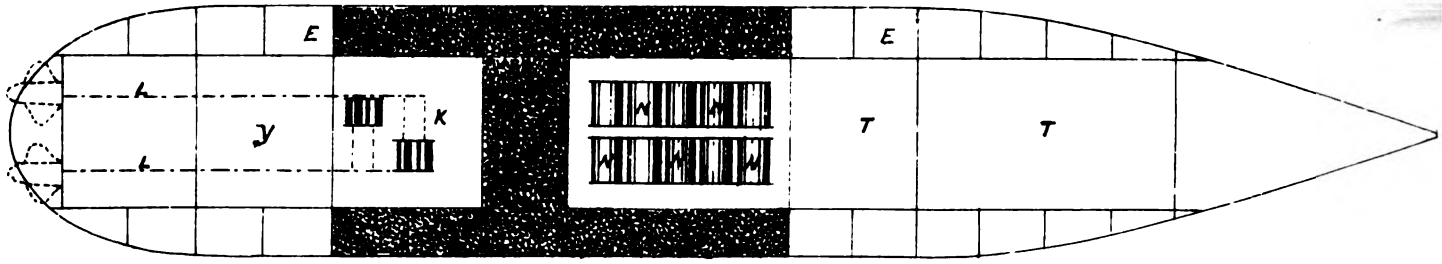
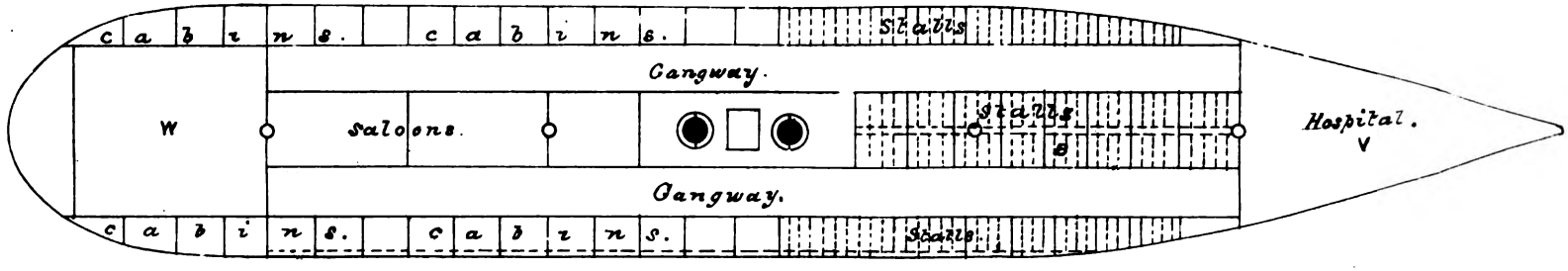


Floor Plan shewing Cellular arrangement of the Coal-Bunkers.

FIG. 2.



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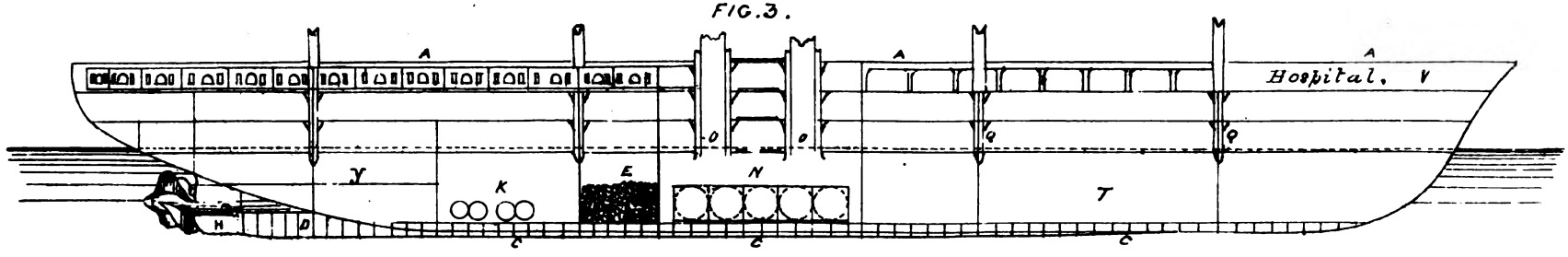

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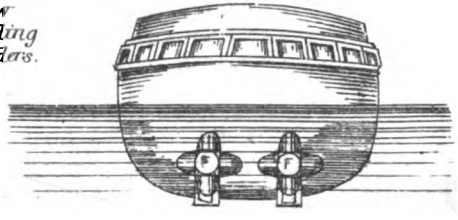
Stern View shewing non-fouling Propellers and Rudders.



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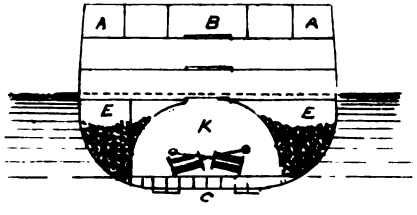

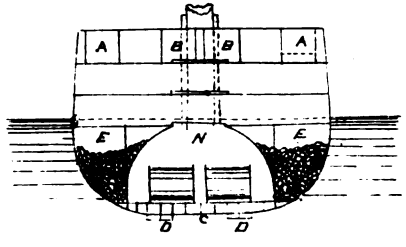

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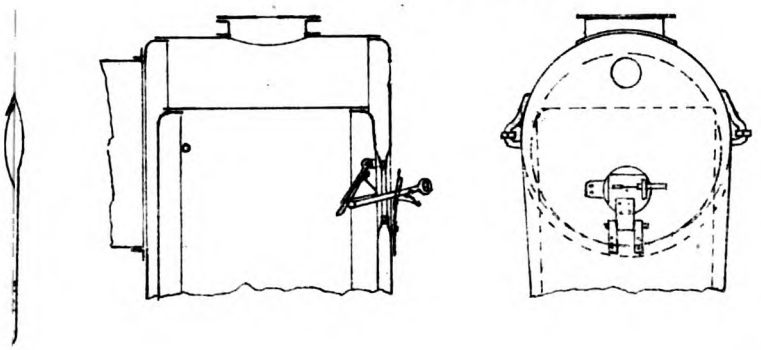

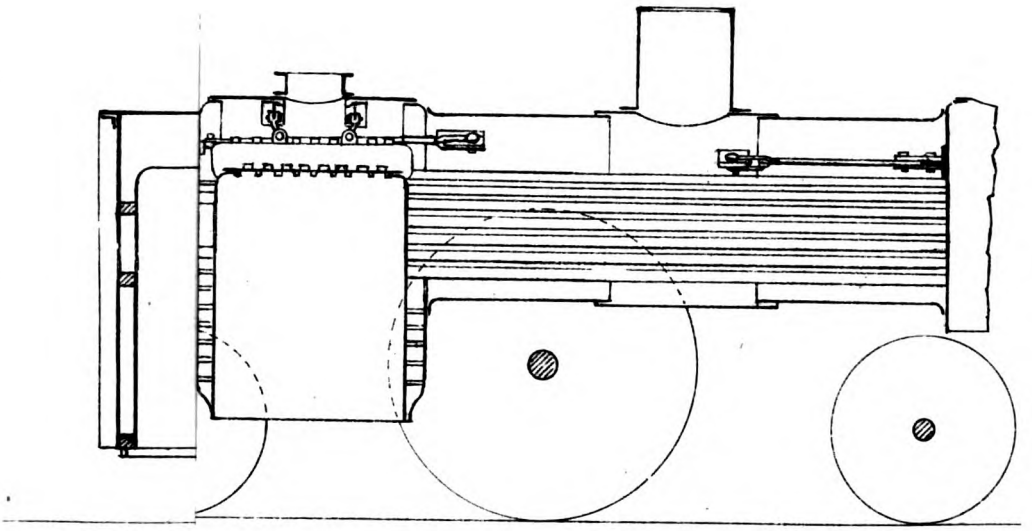

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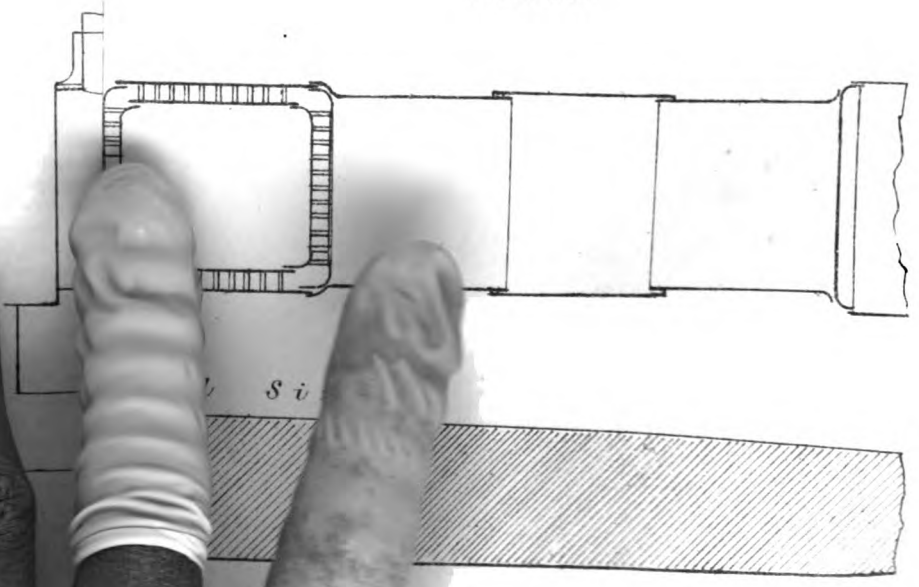

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THE ARTIZAN.

No. 1.—Vol. 1.—Third Series.

JANUARY 1st, 1863.

"ARTIZAN" ADDRESS, 1863.

With the present number we commence the first volume of the third series of the ARTIZAN, and the twenty-first volume from the commencement.

During the past twenty years we believe that the ARTIZAN has proved more thoroughly useful, because of a more practical and utilitarian character, than any of its contemporaries; and no scientific journal has more faithfully performed the task originally undertaken, or from time to time imposed, and we have but to invite the perusal of the published numbers of the ARTIZAN to justify most fully our assertion.

On previous occasions we have, at the advent of the new year, given in our annual address a brief summary of the more important events which have occured during the previous twelve months; upon the present occasion we think it only necessary to refer our readers to the pages of the ARTIZAN itself for the best epitome of all that is material or useful which has occurred during the year just closed, and this we are enabled to do from the improvements which have recently been effected in the body of the work, by which greater space has been obtained for a monthly summary of events, and an increase in the number of scientific papers and reports, which we have thus been enabled to admit; we have also the gratification of being able to direct attention to the increased number of illustrations which we have given of highly-interesting subjects during the past year.

The publication of a series of supplements, illustrating the most novel and interesting of the objects exhibited at the International Exhibition, has enabled us to describe and illustrate very many subjects, without encroaching upon the space of our regular issue.

The International Exhibition of 1862, has been the great event of the year, and doubtless would have been a much greater success, in every respect, but for the much lamented death of his Royal Highness the Prince Consort, the deplorable internecine war raging in America, and the great distress which has been produced amongst the operatives of the great cotton spinning district of this country, from the want of the raw material —cotton.

Of the various Scientific Societies whose proceedings we usually report, the Institution of Civil Engineers, during the last session, produced papers of only average quality, nothing of very great importance having been brought before the institution. The Institution of Mechanical Engineers (Birmingham), the Institution of Engineers in Scotland, and the Scottish Shipbuilders' Association, have each had numerous papers, highly interesting and valuable contributions to practical science. Indeed, it has become a subject of ordinary conversation that there is a total want of that robust vitality in the London Institution of Civil Engineers which is found in the more northern Scientific Societies.

Another attempt is about to be made, by the Atlantic Telegraph Company, to connect Europe with North America, by a submarine telegraph cable, and it is to be hoped they will be more successful than on the previous occasion. The Indian Council have decided upon undertaking at a cost, it is said, of £300,000, the construction, and laying of a submarine cable across the Persian Gulf.

Beyond the International Exhibition, with its magnificent display of machinery—British and foreign, there is but little which calls for special mention here, as having occurred in connection with the various subjects of which our Journal treats. During the past year we have lost several engineers and men of science, whose deaths have been recorded in our pages. The various trials of the novel ordnance and projectiles, as also of the various contrivances for armour plating, or defensive coating for war-ships, have been noted. All that is novel in connection with the improvements in marine engines, and machinery for the war and mercantile marine, the various improvements in naval constructions and in steamship performance, have been given as fully as heretofore. The locomotive engine and railway machinery, and the various other improvements connected with the construction and working of railways, have received due attention; and generally the progress of mechanical science has been carefully recorded in our pages, and every branch of manufacturing and other industries have received their share of attention; in short THE ARTIZAN will be found to be a complete record of all that is valuable in connection with the useful arts and sciences.

It has been our constant aim to guard against the mistake commonly committed in class publications of advertising, under the cloak of a scientific notice, mere schemes, however worthless, and of bestowing praise and claiming merit for inventions indiscriminately, simply because they have been patented, or are illustrated pictorially. It is this practice, which, having been pursued by some of the class journals of this country, has lowered the estimation in which they were formerly held amongst scientific men, to the level of a mere advertising sheet. Our endeavour has been to exclude everything which will not bear the test of practical experience derived from past practice, and in making selections of subjects for illustration and for papers in our monthly issue, we have sought to give only such as would increase the stock of practical knowledge, and advance it a step further in the right direction—in this we have been aided by numerous friends and old contributors to the pages of THE ARTIZAN, and for which aid we are exceedingly grateful.

Notwithstanding the large number of copper-plate engravings and other illustrations which we have given during the past year, there are still several subjects which remain uncompleted for want of accurate details, or for some other equally good reason—but these will be published with all possible speed.

The practice which we introduced some time ago of using both sides of the folding and other sheets for illustrations, and which we have hitherto confined to outline sketches, composite plates, and transfers from wood and stone, we purpose in future to extend to the regular ARTIZAN copper-plate engravings, by which means we hope to so increase the number of plates, as to still further enhance the value of THE ARTIZAN.

We have also made arrangements by which further improvements will, from time to time, be introduced in the body of the work during the current year, whereby additional value will be given to THE ARTIZAN as a standard work of reference.

We have also arranged that in future our country and foreign subscribers and others, connected with engineering, and other branches of mechanics and manufacturing operations, who may have occasion to visit London, shall have at the Publishing Office every facility afforded them, without expense, for obtaining whatever information, advice, or assistance they may stand in need. This has been strongly urged upon us by numerous subscribers and friends during their visit to the International Exhibition, and we readily adopt the suggestion, and invite those who wish to avail themselves of these facilities to do so whenever and as often as they please; and, having correspondents in every important city throughout Europe and America, in addition to our possessing a very extensive acquaintance amongst manufacturers and others, we believe that the suggestion which has been made to us, and which we are now prepared to act upon, will prove of considerable service to our country and foreign friends.

When we look back to the time of the first issue of THE ARTIZAN, and refer to the early volumes, when a portion of each number was devoted to the reports of the meetings of the "Artizan Club," and we cannot but observe the vigourously-healthy tone which then pervaded the work, and the true smack of sound practical knowledge and sterling common sense which cropped out everywhere, and showed THE ARTIZAN to be then in advance of the period and its contemporaries. The original and peculiar style adopted by the projectors of THE ARTIZAN Journal for conveying a vast deal of very valuable practical stuff to those whom they addressed, soon told upon the success of the Journal, which became well established amongst engineers and practical mechanics, both north and south of the Tweed, and from thence it became known, and its sphere of usefulness was extended throughout Europe and America, and the tide of its popularity has continued to flow onward, year by year, until we are able to say, with truth, what be believe cannot be said of any other monthly scientific journal, that it is read and studied in every part of the world where English skill or enterprise has penetrated.

We look forward to an extension of the support which THE ARTIZAN has received, and we believe deservedly, during the last twenty years, and perhaps more especially during the last six or seven years; and we shall be pleased to receive from our friends as heretofore any suggestion with which they may favour us for the improvement of the Journal.

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THE CONSTRUCTION, MANŒUVRING, AND PROPULSION OF SCREW STEAMERS.

(*Illustrated by Plates* 227 *and* 228.)

We published in our last issue, under the head of "Notes and Novelties," an account of the trial trip of the double screw steamer *Flora;* and, as the subject of the application of double screw propellers was very ably treated upon by Commander T. E. Symonds, R.N., in a paper read by him some few months ago, at a meeting of the United Service Institution, we give herewith two plates illustrative of some of the most important points in Captain Symonds's paper.

Plate 227 illustrates a series of views from a model of an armour plated light-draught coast defence ship of about 2300 tons; length, 240ft. breadth, 45ft.; draught, 15ft.; mounting 14 guns, 8ft. 6in. above the water; jointly designed by Commander Symonds and Mr. R. Roberts, C.E., to meet conditions suggested by Rear Admiral George Elliot, and submitted by him last year to the Admiralty and War Office.

Fig. 1 is a general exterior view showing a proposed method of protecting the guns by inclined armour-plated sides, rounded from the deck upwards, terminating in a rounded platform or deck; the top sides forward and aft being fitted to lower when bow or stern guns are used.

Fig. 2. Deck plan, showing a method of giving ventilation and light, and relieving the gun-deck from smoke by a strong iron grating, R, in which are hatchways for giving access to the deck, for boarding or repelling boarders. R R are other hatchways, similarly fitted for ventilation and access to other parts of the ship.

Fig. 3. Longitudinal section, showing internal arrangements. T. Bread and dry provision room. K. Engine room. E. Athwart ship coal bunkers. N. High-pressure cylindrical boiler, with method of fitting the uptake to funnel, and the cellular casing round the funnel to give ventilation in the boiler room, the same arrangement being provided round the masts to ventilate between decks. The funnel is telescopic; when run down projects only three feet above the deck in action, the draught being given by the apparatus referred to above. U. The magazine. V. Chain locker. W. Windlass. X. Form of stem for receiving the prow of ram, and method of strengthening the bows to resist the shock, being a series of short decks or breast hooks.

Fig. 4. Floor plan, showing arrangement of longitudinal bulkheads, forming cellular girders, with the side applied as coal bunkers, water tanks, and other purposes.

Fig. 5. Stern view, showing propellers, and three stern chase guns, with gunwale lowered on starboard side.

Fig. 6. Section in engine room, showing proposed arrangement of engines, K; coal bunker, E; with cellular bottom and keels, C, D.

This vessel is intended for the defence of harbours, or to cross the Channel if required, being quite capable of taking the sea, and may be rigged either as a schooner or polacca. She is fitted to act as a ram, and, from her great longitudinal strength, imparted by the cellular mode of construction adopted, should, we conceive, be specially adapted for that purpose, as also from the fact of the two screws giving her the power of turning in her own length, and, being steered by them, going ahead or astern without assistance from the rudders; in fact, under steam the rudders are unnecessary.

It will be seen on reference to Plate 227, that it is proposed to use a form of high pressure boiler and method of connecting with the uptake, well calculated to overcome the very serious drawbacks attendant upon the existing boiler arrangements of our war steamers and gunboats, more specially,—some ofwhich have two sets of low-pressure boilers, one reaching nearly to thedeck for ordinary purposes, styled "working boilers," which, being exposed toshot, cannot and are not intended to be used in action. The other set, placed lower, but occupying greate rfore and aft space, are called "fighting boilers."

The arrangement for the "uptake" of the furnaces allows one boiler to be cut off without interruption to the remainder; the cellular casing around the funnel will ventilate and lower the temperature of the boiler-room besides giving additional support and protection to the funnel; and instead of the stokers being between two long rows of furnaces, they stoke from opposite sides, which must necessarily improve their condition.

The coal bunkers, E, on either side the boiler and engine-rooms, and athwart ships will add to the security of both, defending them from any shot that may either penetrate the armour plating or strike below it.

The plan of fitting the coal bunkers forms an important feature in the cellular system, and adds materially to the longitudinal strength, so specially requisite in light-draught ships, in which "the beam" is of decreased depth.

The coal bunkers in large ships may be filled expeditiously by means of small carriages running on a tramway, the cells being made to communicate with one another, so that the coals can be readily removed if required.

In this cellular arrangement much coal trimming will be dispensed with, as coal may be taken from any required cell of the bunker without the remainder shifting.

It is proposed to arm this vessel with 14 guns, two of which are to be of very heavy calibre, one forward and the other aft, being bow and stern chasers, firing in a line with the keel side guns, by shifting them, there being spare ports for the purpose. Thus, three guns can be brought into action, whether chasing or retiring, and six on each broadside.

This plan of defending the guns, in addition to the advantage of having a battery of three guns forward and aft, will reduce the weight of hull and armour-plates.

Plate 228 illustrates the model of a larger passenger or troop-ship, constructed upon the proposed plan of Mr. Roberts and Captain Symonds.

Fig. 1. Being a plan taken through the engine-room.

Fig. 2. Deck plan, with arrangement of cabins, stalls, and saloons.

Fig. 3. Is a longitudinal section showing the arrangement of cellular girders formed by cabins, stalls, keels, &c.

Fig. 4. Stern view, showing non-fouling propellers and rudders.

Fig. 5. Transverse section showing stalls.

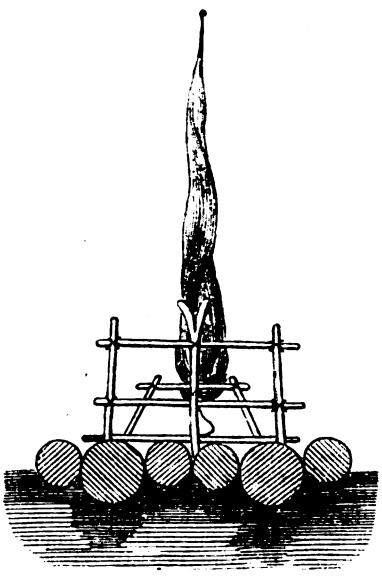
Fig. 6. A midship section.

In these several views A is the cellular girder, formed of cabins, stalls. keels, &c.; B, midship girder, formed of saloons or stalls; C, cellular bottom; D, cellular girder keels; E, cellular arrangement of coal bunkers, &c., extending fore and aft; F, non-fouling screw propeller; G, the trunk to which the propeller is fitted; H, rudders, or steering-blades; K, engine-room; L, screw shafts; N, boilers and boiler-room; O, funnel with casing; T, fore-hold; U, after-bold; V, hospital; W, officers' mess-room.

As regards the cellular girder system, Mr. Roberts appears to have been the first to recognise the necessity for giving greater longitudinal strength to iron ships; and, in promulgating the principle of his patent, he has also compared a ship to a beam, and that, as a beam, it was desirable to increase the sectional area of the iron in the upper part of the hull, and thus secure the utmost strength due to whole depth of the ship's side from gunwale to bilge; this cellular girder system being so arranged as to enable the greatest amount of strength to be obtained at the top and bottom without a corresponding increase of weight, and without interfering with existing arrangements.

Another peculiar feature in connection with Mr. Roberts' plan, is the employment of two cellular keels in addition to the cellular bottom (which latter, according to the last patent of Mr. Roberts', is continued the whole length of the ship). The cellular keels, which extend nearly the whole length of floor, are placed one under each bilge, and are in part cellular girders, and should be, we believe, well calculated to resist the rolling of the vessel and increase her strength, without interfering with the steering.

Capt. Symonds, in the paper under notice, very aptly compared the use of these double keels as increasing the weatherly qualities of a vessel, to the two large logs employed in that most weatherly of all craft afloat, the Pernambuco Catamaran (see adjoining figure).



We agree with Capt. Symonds that a light draught ship, whether for war or mercantile purposes, must possess decided advantages over those of heavy draught on numerous occasions, and especially when intended to operate inshore, when they may then evade them by crossing shoals or bars and take shelter under batteries (and attack them).

The next important feature in connection with the subject of Captain Symond's paper, is the application of double screw propellers. It is well known that good results have in many instances been obtained from vessels fitted with two screws, even with the existing form of after sections. Now, Capt. Symonds in conjunction with Mr. Roberts, proposes to apply the screws in such a manner as to overcome the greatest objections which are advanced against the application of double screws, viz., that the present

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of after section with the dead wood intervening, does not admit of sufficient diameter, and offers a great obstruction to propulsion and steerage, and, that the speed at which it would be necessary to drive screws of finer pitch would be too high.

The plan, as described by Captain Symonds, is as follows (and will be better understood on reference to our plates 227 and 228):—

It is proposed to use a propeller F, which, by its form alone, is calculated to reject or throw off all impediments, and if striking a hard surface will not receive any serious injury.

The vanes or blades are of wrought iron or steel secured to spiral flanges on the boss, the flanges being covered by a cycloidal casing of wrought iron; the root of the blades being long, and therefore well supported, admits of their being made thinner than those of the ordinary shape in cast metal; being thinner, they displace less water, and consequently absorb less power in turning; being of wrought iron, they are far less liable to injury, and can be readily replaced or repaired when damaged. They may be estimated at about half the weight, and one-third or one-fourth the cost of those made of gun-metal of the same diameter.

These blades are tapered on both the leading and after edges, and when in rotation, whether turning ahead or astern, may be said to form a cone that will throw off any passing wreck, chain, or cordage, without fouling or injury; a coil of rope falling upon this screw would be, it is anticipated, instantly thrown off. This form of blade will also insure a more constant and equable action on the water under all circumstances, and thereby reduce vibration.

The method of attaching the screw shaft enables it to be readily shipped and unshipped, and, being comparatively light, the after bearing is dispensed with, part of the after length of the screw shaft into which the short shaft of the propeller is shipped being of increased diameter, so as to give a sufficient bearing to prevent the weight of the screw wearing unduly, and to admit of being bored out to receive the short shaft attached to the propeller, which is secured by a key, gib, and cotters; by this means the screw and short shaft may be removed without disturbing the main shaft or admitting water into the ship.

There being no aperture for the screw, the section of the ship will be stronger and lighter. The screws are fitted to cylindrical trunks, G, fig. 3, under either quarter, which connect the keels with the counter of the ship; these trunks are the same diameter as the boss of the screws, against which they fit closely, so as to prevent anything getting between them. The rudders, H, being attached to the after extremity of the keels, but before and lower than the screws, so that both screws and rudders are quite clear of each other, and are thus capable of performing their respective functions without hindrance, both being immersed at such a depth as to place them entirely out of reach of shot or ram, and prevent their being lifted out of water. Captain Symonds argues that by this method of fitting the screws, the water being already displaced by the ship and trunks, it comes direct to the screw-blade and closes by its own gravity on the cycloidal boss, leaving an appreciable vacuum, whereas in the ordinary mode, the boss not only displaces a large volume of water, but leaves a considerable vacuum in its wake, which will absorb power, retard speed, and, it is believed, cause vibration.

By reversing either screw, the ship may be turned rapidly by the screws alone, to starboard or port in her own length (as with two sculls in a boat, one backing and the other pulling), and may be steered, going ahead or astern, by these screws, without any assistance from the helm, in the most accurate manner.

The rudders are geared together, and worked by steam or by a wheel on deck, or in the after part of the engine-room, so that in action the engineers and helmsmen receive orders simultaneously, helm and screws acting together on the instant, helmsmen and steering apparatus being out of reach of shot.

It will be seen on reference to our Plates that as the screws will be driven at a higher speed than a single screw of large diameter, it is proposed to use gearing; although if considered preferable, direct action may be used, as being equally applicable. Each of the screw shafts is shown as being driven by two horizontal high pressure engines K, with surface condensers P and multitubular cylindrical boilers N, the whole of which, including the gearing, will be considerably lower than those in use at present. The substitution of far smaller engines in lieu of the large engines now in use would be attended with especial advantage, as the liability to accident must be very considerably reduced, the engines may be more readily replaced or repaired, are less costly, and duplicate parts may also be carried with facility.

We must not conclude this subject without referring to an additional and very important feature dwelt upon by Captain Symonds, viz., the necessity for labour-saving machinery; and we quite agree with him in arguing the great necessity which exists for the more extended adoption of simple mechanical contrivances for saving labour on board ship.

We may add that the models forming the subjects of our plates were exhibited in the Naval Department of the late International Exhibition.

A CRITICAL AND HISTORICAL REVIEW OF LOCOMOTIVE ENGINEERING.

(*Continued from page* 272.)

(*Illustrated by Plate* 229.)

Having analysed the nature and inquired into the magnitude of the various resistances which the engine has to overcome, if we assume the amounts as defined by the several formulæ which we have laid before our readers to be sufficiently accurate for all practical purposes, nothing could be easier now than to define the power which is developed by an engine while it is performing a certain duty. Let us suppose, as a first example, that it is desired to run a train of 100 tons (engine and tender included) up an incline of 1 in 70, at a speed of 40 miles per hour; taking Dr. Rankine's formula as the one nearest the truth, and admitting the resistance due to back pressure to be 27 per cent. of all other resistances, the total resistance at the circumference of the driving wheels will be

$$R\,t = 100\,(1 + 0{\cdot}27)\left(8 + \frac{40^2}{180} + 2240 \times \frac{4}{3} \times \frac{1}{70}\right) = 7561 \text{ lbs.}$$

and the work performed expressed in mechanical horse

$$HP = \frac{7561 \times 5280 \times 40}{60 \times 33{,}000} = 806 \text{ horse} \qquad \ldots 1$$

Or, as a second example, let it be proposed to run a train up an incline of 1 in 70, with a load of 142 tons (engine and tender included), at a speed of 20 miles per hour, taking the back pressure at 22 per cent. of all other resistances, the total resistance at the circumference of the driving wheel will be

$$R\,t = 142\,(1 + 0{\cdot}22)\left(8 + \frac{20^2}{180} + 2240 \cdot \frac{4}{3} \cdot \frac{1}{70}\right) = 9190 \text{ lbs.}$$

and the power in horse developed

$$HP = \frac{9190 \times 5280 \times 20}{60 \times 33{,}000} = 490 \text{ horse} \qquad \ldots 2$$

Upon the mode of arriving at this expression of power in horse or in units of mechanical work, all engineers and all writers on the subject are well agreed, however much they may differ as to the amounts either in detail or in the aggregate; and here, perhaps, will be the proper place to take note generally of Mr. Dixon's remarks on the capabilities of locomotive engines. In his late pamphlet on train resistances, Mr. Dixon finds fault with Mr. Fairbairn for stating in his *Useful Information for Engineers* that the duty performed by one of our largest locomotives, travelling at 45 miles per hour, would exceed 700 horses, and seems to think that no engine had ever, or would ever, perform a duty exceeding 350 horse-power; yet do we find by the foregoing examples, which are by no means exaggerated, that in the first case the engine would perform a duty of 590 horses, and in the second case a duty of 400 horses, deduction being made in both cases for the loss of power by back pressure; and in Clarke's record of Gooch's experiments on the engine "Great Britain" we find that on one occasion, travelling at a speed of 57 miles per hour, it performed an effective duty of 743 horses; and on another occasion, travelling at a speed of 54 miles per hour, an effective duty of 763 horses, the power exerted being measured in both cases from the steam diagram; these several cases, therefore, plainly show that Mr. Fairbairn has by no means overrated the capabilities of the class of engines he referred to, but has simply endorsed a fact recognised by previous writers.

From a careful inquiry we find that, at a very early period in the history of locomotive engineering, those engaged in its pursuit were fully aware of the fact that the seat of power of the engine is in the boiler; for we find in that 1836 Pambour, in his expression of the power of engines, introduces their evaporating capabilities as one of the chief elements of his formula; that in 1846 Brunel, in his evidence before the Gauge Commissioners, says as follows:—"In speaking of powerful engines, I refer to engines of great capacity of steam." That Stephenson says:—"The size of the boiler is the only limit to locomotive power," while the adoption of the tubular boiler and the blast pipe in the elder Stephenson's memorable "Rocket," at the early date of 1829, was unquestionably the result of a conviction that heating surface and rapid combustion are the great means of developing power." It was not, however, until Pambour had made his experiments and published his work that engineers became possessed of a tolerably accurate knowledge either of the power required for the performance of a certain duty upon the permanent road, or of the capabilities of the boiler; indeed, this want of knowledge seems to be plainly evidenced by the slow progress made in the development of the boiler previous to that date, and by the sudden development which followed soon afterwards; thus we find that the heating surface of the "Arrow," built in 1830, amounted to 303 square feet, and that that of the "Goliath," built in 1836, amounted to 360 square feet only, though it was the largest of the

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engines then at the disposal of Pambour; while Brunel, who at the very outset of his career as a railway engineer, in 1833, showed a spirit of adventure of incredible boldness, built the "Ajax" in 1836-7, with 10-feet driving wheels, yet with only 474 square feet of heating surface. In 1838, however, (that is just at the time when those interested in the question must have become acquainted with Pambour's writings,) we find that Brunel designed the "North Star,'; with a heating surface of 706 square feet; and that from that time he kept increasing it in the engines of the Great Western Railway until, in 1846, it reached the almost impracticable amount of 1952 square feet in the "Great Britain." As we find no record of any equally sudden and marked development of the boiler in the engines upon other lines, we feel in justice bound to ascribe to Brunel the merit of having first carried into practice the results of scientific observation, and made the locomotive engine that powerful agent of the purposes of man which we know it to be now; for, indeed, upon the narrow gauge, the first great step in this direction was only made in 1843, when Stephenson patented his long boiler engine.

When Pambour made his experiments, he found that the amount of water evaporated per square foot of heating surface per hour, was about 0·2 cubic feet; this, however, includes the water which is carried along in a globular state with the steam, and which, having no elastic force, is literally wasted; the loss by priming was by him ascertained, by calculation of the work performed, to be about 25 per cent. of the whole amount of water consumed, so that finally the square foot of heating surface had an evaporating capability of 0·15 cubic feet of water only, and the coke required was from 9⅛ to 11⅞ pounds per cubic foot of water, or the amount evaporated per pound of coke from 5⅛ to 6⅞ pounds. Pambour also inferred from his experiments that the best proportion between firebox area and tube area, in regard to economy of fuel is as 1 to 10.

In the rate of *apparent* evaporation per square foot of heating surface it does not appear that we obtain any greater results now than were obtained 26 years ago, for the experiments recorded by Clark, made on various classes of engines, and which we reproduce in the subjoined table show a maximum evaporation of 0·2 cubic feet only.

Engine.	Ratio of Heating Surface to Grate Area.	Water evaporated per sq. ft. of heating sur.	Water evaporated per lb. of Coke.
		Cubic Feet.	lbs.
Orion.....	52	0·12	9
Cal. Railway Pass. Engine .	66	0·13	9·1
Snake (Gooch's)	72	0·17	8·9
Sphynx (Sharp's).....	90	0·20	8·92

These are the mean results of a good number of experiments, and on that account may be considered tolerably trustworthy; from them Clark very naturally inferred that the rate of evaporation increases with the ratio of heating surface to grate area, and on this assumption has constructed the following formula, defining the amount of water evaporated in cubic feet per square foot of heating surface per hour:

$$n\ 0{\cdot}00222\ \frac{A}{a}$$

where A and a respectively represent the heating surface and the grate area. From observations made upon some passenger engines on the Great Eastern Railway, supplied to us by Mr. Sinclair, we gather that with a ratio of heating surface to grate area of 71 to 1, the rate of evaporation is only 0·12 cubic feet, and as these observations are taken from the engines performing their regular work, perhaps they are a more faithful representation of the actual state of things, than observations made with the preconceived ntention of being noted down, when everything is put into the best possible working condition; at the same time it should be mentioned that this result was obtained by engines burning coal instead of coke, and if the tubes had not been newly cleaned, the probability is that they would be covered with a coating of soot, a highly non-conducting substance, which contingency may in some measure account for the somewhat low figure mentioned.

These several results compared with those obtained by Pambour show a rate of evaporation per square feet of heating surface, rather less in modern boilers than the earliest ones; nor are we astonished that such is the case, for, while we have more than trebled the amount of tube surface, the size of the boiler barrel being necessarily limited by the conditions of the gauge, we have at the same time so choked it up, as to greatly hinder the formation, or, at any rate, the liberation of the steam. This fact has not long remained unobserved, for we find that at an early date some engineers have endeavoured to obviate it as much as possible, by increasing the heating surface in the fire box by means of the midfeather, rather than in the tubes; this, we believe, was first done in 1847, by Sharp, in the *Spyhnx* (Fig. 1), and in the *Jenny Sharp* (Fig. 2), and by J. V. Gooch, in the *Snake* (Fig. 3); the *Sphynx*, in particular, has very few tubes, with large water spaces, and to this we feel inclined to ascribe in a great measure the high rate of evaporation of 0·2 cubic feet. With a view to the same object Mr. Fernie of the Midland Railway (see Fig. 4), in his patent boiler, arranges the tubes in vertical instead of horizontal rows, and thus obtains an unbroken vertical water space, through which the steam liberates itself without impediment; this arrangement has been attended with very good results, and as the same number of tubes can be put into the same space as by the old method we can see no reasonable objection to its general adoption.

Reverting to our comparison of modern with Pambour's results, we find a great improvement as regards the loss of water from priming, and in the consumption of fuel; it is true that the experiments recorded by Clark, show a loss by priming and condensation varying from 3 per cent. to 32 per cent., but from a series of 15 experiments on various classes of engines and under various circumstances we find the mean loss to be 18 per cent. only of the total amount of water consumed which, we think, may be taken as a fair average, and which shows a gain of 28 per cent. on the loss sustained in the days of Pambour; on the subject of consumption of fuel, we find also that one pound of coke evaporates now from 8 to 9 pounds of water, showing a gain of 30 per cent, on the results obtained by Pambour, and thus we see that the gain in consumption of fuel is equal to the gain effected on the loss from priming; the one fact, indeed, is a natural sequence of the other, but their concurrence deserves to be pointed out here because it tends to testify to the correctness of the observations recorded by Pambour on the one hand, and by Clark on the other. So far we have not taken into consideration the important item of pressure, but in order to draw an accurate parallel between these several results we should compare the pressures to which the steam in each case had been raised, and see what is the relative quantity of heat required for steam at various pressures. It had been admitted by Pambour that the quantity of heat contained in steam is constant for all pressures, and if such were the case, the question would require no further investigation, since this would imply that it takes no more coal to convert a pound of water into steam of 50lbs., than to conver it into steam of 150lbs. pressure. Regnault's experiments, however, have proved that this assumption is not quite correct, but that there is a slight increase of total heat with the increase of pressure, and for the satisfaction of our readers, we subjoin an abridged table of pressures, temperature and total heat of steam as translated from Regnault's tables.

Pressure.	Temperature.	Total Heat.	Pressure.	Temperature.	Total Heat.
lbs.	Deg.	Units.	lbs.	Deg.	Units.
15	213	1147	90	320	1179
30	250	1159	105	331	1182·6
45	274	1164	120	341	1185·3
60	292	1170	135	350	1187·6
75	307	1174·4	150	358	1190

From a perusal of these figures which show such a trifling increase of total heat that in practice it cannot possibly be felt, we are compelled to conclude that Pambour's assumption remains practically correct and consequently that, although modern engines are worked at nearly treble the pressure at which they were worked in his days, yet does the steam as now used not necessarily require a greater amount of fuel. It follows, also, from the preceding remarks, that an engine becomes more economical in proportion as the boiler is made to generate steam at a higher pressure.

We have learned in the first portion of this paper how to express in units of mechanical work the power developed by an engine in the performance of a certain duty, and we have now seen what are the steam generating capabilities of the boiler, along with the loss of power sustained from priming and condensation; provided, therefore, we can ascertain what volume of steam is required for each horse-power developed, it will be a simple matter to design a boiler capable of producing a given required power. This at any rate seems to be the most natural, and is, perhaps, the simplest mode of procedure; but when we remember that steam may be worked with or without expansion, and that an engine may be made to run at slower or higher speeds, the question naturally presents itself: under which of these conditions does the engine yield its maximum power? For it is evident that the problem should be made subject to this condition, since the engine can be made to yield any power inferior to its maximum. In

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order to solve this question, Pambour first finds the expression of power at *any* speed with *any* pressure, and finding that in his formula, obtained from purely theoretical considerations, the factor *speed* appears only as a negative term, he naturally infers that the engine yields its maximum power at the lowest possible speed for a given pressure; and, as the total pressure could never be less than the resistance to be overcome, the condition of the maximum will be realised when the pressure upon the piston, reduced to its value at the circumference of the driving wheel, is equal to the resistance to be overcome, for, if it were greater, the surplus pressure would act as an accelerating force, and the condition of minimum speed would at once be destroyed. When, therefore, the data of the maximum duty are given, and the resistance at the driving wheel ascertained, as in the case of formulæ 1 and 2, nothing could be simpler than to define the *mean actual pressure* upon the piston, and, this being done, the following mode of procedure will lead us to the proportions of the boiler. The speed of the piston is evidently regulated by the volume of steam which has to pass through the cylinders; and, if S be the number of cubic feet of water evaporated per hour, and μ the relative volume of the steam at the mean *absolute* pressure at which the work has to be performed (that is, the mean actual pressure, augmented by 15 pounds, for atmospheric pressure), the volume of steam to be sent through the cylinders in one hour will be μ S; on the other hand, the capacity of the cylinder, including clearance and steam ways, which we will take at $\frac{1}{25}$ the value of the stroke, is $\frac{1}{4} \pi d^2 1{\cdot}04\, l$, d and l being respectively the diameter of the cylinder and the stroke, both expressed in feet; and as there are 4 cylinders full of steam to be discharged for every revolution of the driving wheel, the number of revolutions per hour will be

$$\frac{\mu S}{1{\cdot}04\, \pi\, d^2\, l}$$

and the speed of the engine in miles per hour

$$v = \frac{\pi D}{5280} \cdot \frac{\mu S}{1{\cdot}04 \cdot \pi\, d^2\, l} = \frac{D}{d^2\, l} \cdot \frac{\mu S}{5491} \quad \ldots\ldots\ldots\ldots (3)$$

where D stands for the diameter of the driving wheel in feet, and v for the speed in miles per hour; from this equation we find for the volume of water required per hour for a given speed

$$S = v\, \frac{5491}{\mu} \cdot \frac{d^2\, l}{D} \quad \ldots\ldots\ldots\ldots (4)$$

Such would be the expression of S at any rate, if we did not work the steam expansively; but, as in modern engines, the greatest admission possible is 0·75 of the stroke, and as the relative duty of steam at this rate of expansion is 1·28, we must correct formula (4) by dividing by 1·28, in order to obtain the correct value of S, which becomes

$$S = v \cdot \frac{5491}{1{\cdot}28\, \mu} \cdot \frac{d^2\, l}{D} \quad \ldots\ldots\ldots\ldots (5)$$

And, as we know that every square foot of heating surface can evaporate 0·16 cubic feet of water per hour, deduction being made for the loss of priming and condensation, if A be the heating surface of the boiler in square feet, we shall have

$$0{\cdot}16\, A = S = v \cdot \frac{5491}{1{\cdot}28\, \mu} \cdot \frac{d^2\, l}{D}$$

and, finally,

$$A = \frac{S}{0{\cdot}16} = v \cdot \frac{34318}{1{\cdot}28\, \mu} \cdot \frac{d^2\, l}{D} \quad \ldots\ldots\ldots\ldots (6)$$

remembering always that μ is the relative volume of the steam at the mean absolute pressure at which the engine will have to work. It will be perceived that this is not an empirical formula, but one arrived at by theoretical considerations of unquestionable correctness; the factor μ is the only one obtained by means of an empirical formula, but the accuracy of the tables of relative volume of steam, as corrected by the experiments of Regnault, Rankine, or Fairbairn, cannot be doubted, at any rate to any practically appreciable degree, and, as regards the co-efficient of evaporation, that is obtained from experimental evidence. As an instance, let it be proposed to construct an engine capable of performing the maximum duty embodied in formula (2), with a cylinder 16in. diameter and 22in. stroke; the total resistance at the circumference of the driving wheel was found to be 9190lbs., back pressure included, and, therefore, the mean actual pressure p_1 upon the square inch will be

$$p_1 = \frac{9190 \times 5{\cdot}5 \times \pi}{0{\cdot}785 \times 16^2 \times 4 \times 1{\cdot}83} = 108\,\text{lbs.}$$

the diameter of the driving wheel being taken at 5ft. 6in., and the mean absolute pressure will be 108 + 15 = 123lbs.; the relative volume of steam at this pressure is 243, by the old tables, and the heating surface required will be

$$A = \frac{34318}{1{\cdot}28 \times 243} \times \frac{1{\cdot}33^2 \times 1{\cdot}83}{5{\cdot}5} \times 20 = 1300 \text{ sq. feet.}$$

It should be remarked here that this mode of procedure is applicable to passenger as well as to goods' engines, for since the case of maximum power is that of minimum speed; conversely also is the case of minimum speed that of maximum power, and, consequently, if an engine be proportioned to yield its maximum power at a given minimum speed, it may be made to work at any higher speed which is practically attainable; for instance, if we would proportion an engine capable of performing the maximum duty embodied in formula (1), with a cylinder 17in. diameter and 22in. stroke, at the minimum speed of 40 miles per hour, the total resistance at the circumference of the driving wheel having been found to be 7561lbs., back pressure included, the mean actual pressure per square inch on the piston will be, with 8ft. driving wheel,

$$\frac{7561 \times 8 \times \pi}{0{\cdot}758 \times 17^2 \times 4 \times 1{\cdot}83} = 115\,\text{lbs.}$$

and the absolute pressure 115 + 15 = 130lbs.; the relative volume of steam at this pressure is 231, and as the engine at this speed would be worked with an admission of 0·50 of the stroke, at which degree of expansion the relative efficiency of steam is 1·69, we should find the heating surface required to be

$$A = 40 \times \frac{1{\cdot}69 \times 231}{34318} \times \frac{\overline{1{\cdot}417}^2 \times 1{\cdot}83}{8} = 1605 \text{ sq. ft.} \quad \ldots\ldots (7)$$

Sewell, in his edition of Tredgold, has constructed an empirical formula to define the horse power of a locomotive boiler in terms of the heating surface exclusively, from which, of course, the heating surface may be calculated when the horse power to be developed is given; his formula stands thus:—

$$HP = 3 \sqrt{(\tfrac{1}{2}\, a + t)\left(\tfrac{1}{2}\, \frac{A_1}{9}\right)}$$

where a represents the area of the vertical sides of the fire box, t the area of the top, and A_1 the area of the tubes. Now the top of the fire box is generally about $\frac{1}{4}$ the area of the sides, we may, therefore, put $\frac{1}{2}\, a + t = \frac{3}{4}\, a$, and again the area of the sides is generally abont $\frac{1}{12}$th that of the tubes, so that finally we may put $\frac{3}{4}\, a + t = \frac{3}{4}\, a = \frac{1}{16} A_1$; Sewell's formula may, therefore, be put into this shape:

$$HP = 3 \sqrt{\frac{1}{16}\, A_1 \times \frac{1}{18}\, A_1} = \frac{3}{17}\, A_1$$

whence,

$$A_1 = \frac{17}{3} \cdot HP.$$

but as the fire box area is to be $\frac{1}{10}$ that of the tubes, if A again be made to represent the total heating surface we shall have

$$A = \frac{11}{10}\, A_1$$

and finally

$$A = \frac{18{\cdot}7}{3}\, H.P. = 6{\cdot}23\, HP$$

If this formula be applied to the case previously instanced where the maximum power, exclusive of back pressure, was to be 400 horse, we shall find

$$A = 6{\cdot}23 \times 400 = 2490 \text{ sq. feet.}$$

This figure, we think, is sufficient in itself to condemn Sewell's formula at once, for there has never yet been a locomotive boiler made with a heating surface much exceeding 2000 square feet, and we have seen in the case of the *Great Britain*, that engines of this class yield an effective power of upwards of 750 horses.

Clark defines the horse power of the engine in terms of the grate area, and obtains the heating surface by laying down the rule that it should be equal to 80 times the former; his mode of procedure is as follows: he first ascertains the amount af water, in pounds, required per effective horse power per hour, and from Gooch's experiments on the *Great Britain*, makes it to be,

$$\text{lbs. water per effective horse per hour} = 22 \cdot e + 14$$

where e is the period of admission in percentage of the stroke. This formula which tells us that 14lbs. of water are lost by back pressure, priming and condensation, and clearance for all grades of expansion is based upon three mean results of nine experiments, a very slender foundation indeed, it must be owned, for a formula of so much importance; but, as we have the means to test its accuracy, it will be well to do so: since the loss by back pressure is laid down at about 24 per cent. of the whole, and the loss by priming, condensation and clearance at 18 + 4 = 22 per

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cent., the total loss of water amounts to 46 per cent., and we should, therefore, have the following proportion,

$$100 : 22 . e + 14 :: 46 : 14$$

which calculated for the maximum admission of 75 per cent. of the stroke stands thus:

$$100 : 30{\cdot}5 :: 46 : 14$$

or, $$1400 = 1403$$

The formula, therefore, may be said to be practically correct for the case of maximum admission, so far at any rate as regards the ratio of total expenditure to loss; but if it is calculated for any other period of admission, the above proportion must become an impossibility, for since the total percentage of loss remains very nearly constant, three of its terms will remain unaltered, while one of them changes, when the proportion necessarily ceases to be true, in the case of an admission of 40 per cent. for instance, it will stand thus:

$$100 : 23 :: 46 : 14$$

or, $$1400 = 1058$$

which is an absurdity.

From the above consideration we are forcibly led to the conclusion that there is no such thing as a constant loss of 14 pounds of water per horse per hour for all grades of admission, but that this loss must vary in the same ratio as the total consumption, provided the per centage of total loss of power remains constant; but if it be satisfactorily proved that this latter loss varies in a certain ratio, the loss of water must vary at the same time, also inversely in the latter ratio.

We have found, however, that the formula works well in the case of maximum admission, which is also the case of maximum power, if, therefore, we assume it to be correct in its amounts and proceed according to Clark's method, we shall find the amount of coke consumed per horse per hour by dividing by 8, thus:

$$\text{lbs. coke per horse per hour} = \frac{22 \times 0{\cdot}75 + 14}{8} = 3{\cdot}81\text{lbs.}$$

and for a given number of effective horse-power,

$$\text{coke in lbs.} = 3{\cdot}81 \text{ HP.}$$

Now it is found that one square foot of grate area can burn a maximum of about 100lbs. of coke per hour, and consequently we shall find the grate area, if we divide the above result by 100, thus:—

$$\text{grate area in square feet} = 0{\cdot}0381 \text{ H. P.}$$

but as the heating surface is to be 80 times the grate area, if we call it A again we shall have finally:—

$$A = 80 \times 0{\cdot}0381 \text{ HP.} = 3{\cdot}05 \text{ HP.} \quad \ldots\ldots\ldots\ldots\ (8)$$

This formula calculated for the case selected to illustrate Pambour's method where the maximum power was to be 400 effective horse gives a heating surface,

$$A = 3{\cdot}05 \times 400 = 1220 \text{ sq. feet.}$$

a result which is only very slightly inferior to that found with Pambour's method, and from their comparison we have a right to infer that Clark's formula is correct also in its amounts, for the case of maximum power, but as it is altogether empirical, while Pambour's is theoretically correct, we should decidedly prefer the latter.

The several results which we have laid before our readers, have been obtained with the consumption of coke, and formulæ 6, 7, and 8, are constructed under the hypothesis that this will be the fuel used, but of late years great efforts have been made to substitute the much cheaper material coal for coke, the price of the former being rather less than one-half the latter, and since at the present date coal has found its way into almost exclusive use, it behoves us to see whether with this change of fuel, any of the primary data upon which these formulæ are based have also altered, to see in fact whether as much heat can be developed in a given time by the combustion of coal as by that of coke, and whether the unit of heating surface remains as effective as before. With this object in view, we ought perhaps, to refer to the chemical composition of coke and coal, but without entering into minutiæ which would not tend to the furtherance of our present object it will be sufficient to state that coke which is composed of solid carbon with a small per centage of ashes can develope on an average 12,500 units of heat, and that coal which is composed of about 60 per cent. of solid carbon with 25 per cent. of carburetted hydrogen can develope an equal amount of heat, and according to some French authorities may even develope more; theoretically, therefore, a pound of coal should evaporate as much water as a pound of coke, and this very nearly does take place in well managed stationary and marine boilers. Clark, however, states that in the locomotive boiler, he has found coal to be capable of rendering a duty of two-thirds that of coke only; and the result of actual practice on the London and North Western Railway as reported to us by Mr. Ramsbottom, confirms Mr. Clark's observations; there is, therefore, in the combustion of coal a loss of one-third, which must be accounted for, first by the imperfect combustion of portions of the solid coal which drop through the fire bars, and by the imperfect combustion of the volatile hydro-carbons which escape through the chimney in the shape of smoke; these are the two most palpable causes, but in our opinion, as already mentioned, the deposit of soot in the tubes, rendering them less capable of conveying the heat to the water, is a no less active cause of the loss stated; this latter view of the subject, so far as we are aware, has not before been propounded, and though practically it may be of little importance to know where the greatest amount of the loss is sustained, yet as an abstract question it is of sufficient interest to deserve special investigation.

The adoption of coal as the staple fuel for locomotive purposes is, however, of such recent date that engineers have not reached the point, and probably will not soon reach it, when they may turn their attention to the question of loss of heat and loss of evaporating power, their only endeavours having been, until now, to devise means for the prevention of smoke, in order to meet the requirements of the Act of Parliament, which forbids, not the coal, but the chimney to emit smoke; and were we to detail before our readers the many schemes that have been patented and tried with a view to the solution of this important problem, their number truly would be found to be *legion*; although, theoretically, the question is as simple as possible, since the only thing required is to supply those volatile hydro-carbons with a sufficient quantity of atmospheric air at a point just above the first source of heat, where the temperature is sufficiently elevated to enable carbon and hydrogen to disunite and to combine with the oxygen of the fresh air. Practically, however, the problem is fraught with several great difficulties not easily to be overcome; it is difficult, in the first place, to supply the air just at that point over the surface of the fire where the temperature will allow those chemical changes to take place; it is still more difficult to supply the air in such a manner as to mix it so perfectly with the gases of combustion that each particle will have a chance of meeting with the necessary equivalent of oxygen; and although the various schemes that have been tried have not all aimed at these two objects directly, yet has their number been proportionate only, we think, to the difficulty of the problem. We shall lay before our readers a few only of them, with a view especially to illustrate the fact that truth is often looked for in far-fetched, difficult, and expensive schemes, while afterwards it is more closely approached by contrivances of the greatest possible simplicity.

As early as 1837 we find that attempts at constructing coal-burning locomotive boilers were made by Messrs. Gray and Chanter, of the Liverpool and Manchester Railway; but, confining ourselves to more recent practice, we meet first with Mr. M'Connell's boiler (fig. 5), patented in 1852, in which the prevention of smoke was aimed at first by providing a large grate area, in order to obtain a liberal supply of air from underneath; secondly, by prolonging the fire-box a considerable distance into the boiler barrel, in order to give the gases of combustion as long a run as possible previous to entering the tubes, while it was sought also to facilitate their oxidation by means of a limited supply of air admitted through apertures in the fire-hole door; and, thirdly, by dividing the fire-box longitudinally into two chambers, and thus providing for alternate firing upon two distinct grates. It will be perceived that the theoretical requirements of the problem are far from being attained in this scheme, for the free access of air through the grate would but stimulate the rapid distillation of the coal, while the small supply of fresh air from above, admitted at a point so far distant from the surface of the fire where the temperature is too low already to permit of its chemical combination with the volatile portion of the coal; and practice has confirmed its inefficiency, for the experiments made by Messrs. Woods and Marshall, as recorded by Clark, show that when fired with coal, this boiler only evaporates two-thirds the amount of water evaporated with coke. It is true that Clark says, "with good management it is effectual in preventing smoke," but here we must remind our readers that any fire, when it is well managed, burns coal with little smoke.

The next scheme (Fig 6), originated by Mr. Forston, was patented by that gentleman and Messrs. Sharp, Stewart, and Co., in 1855. Here the intention was to burn coke and coal simultaneously, the coke lying to the front, and the coal to the back of the fire box, and each portion of the grate was fed through a separate door; the fire box was literally divided into two compartments crossways by a curved midfeather connected with the back of the box and with the sides, but stopped short at a distance from the bottom sufficient to allow of a single system of fire bars being used for both fires; the mid feather was perforated with a series of hollow stays to allow the gases of combustion from the coal fire to escape, and a stream of fresh air was supplied from below close against the back of the fire box. With this scheme it was evidently expected that the combustion of the volatile portions of the coal would be completed after their passage into the front compartment of the box where it was supposed, no doubt, a sufficient amount of oxygen would be found for the purpose, and the separate current of air from underneath, apparently was expected to glide up, unchanged

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at the back where its temperature would be raised considerably, to assist afterwards in the combustion of those gases in the upper region of the fire box; we are, however, unable to supply our readers with the practical results obtained by this experiment.

Almost simultaneously with the plan just described, Mr. Beattie of the South Western Railway, brought out his design, illustrated by fig. 7, which was intended to burn coal only. In this, as in the previous case, there are two distinct furnaces, and the fire box is divided into two compartments partly by an inclined midfeather, and towards the crown by an arch made of perforated fire bricks; the furnace to the back is the one most actively worked, and the one to the front is intended chiefly to carry incandescent fuel, so that the gases of combustion, issuing from the back furnace, and deflected by a hanging diaphragm may meet with gases at a higher temperature in the front compartment; the fire tiles also are intended to act as a reservoir of heat, raising the temperature both of the air let in through the upper firing door, and of the gases emerging from the back compartment. As in Mr. M'Connell's design, the fire box projects some distance into the boiler barrel, and in this front combustion chamber, there is again a diaphragm of perforated fire bricks to act as a reservoir of heat, and to promote a more perfect mixing of the gases in order to facilitate their entire combustion previous to entering the tubes.

This design, therefore, may be said to be a compound of M'Connell's and of Yorston's, with the only novel feature of the interposition of perforated firebricks, which we certainly are inclined to consider as an improvement; and if we are to put faith in the results of experiments made to test its efficiency as recorded by Clark, we cannot but conclude that it has given the most satisfactory results; for in this record we find that on one occasion it actually evaporated 10 lbs. of water per pound of coal, and that the average performance of 12 experiments was 8·6lbs. water per pound of coal, against 7·7lbs. per pound of coke. Time, however, has not verified those extraordinary performances, and at this date Beattie's coal burner belongs to the things of the past. The various schemes brought out since 1857 have all been much less pretentious than the previous ones, and proportionately also have they been more practical; indeed, with a few exceptions, they seem to have all had a tendency to realise the plan now adopted by Mr. Ramsbottom (illustrated by fig. 8) on the extensive net work of the London and North Western Railway, and consisting of a couple of air holes in the front of the fire-box, through which the admission of air is regulated by means of small dampers, a brick arch leaning from the tube plate slightly downwards to throw the fresh air upon the surface of the fuel, and also to increase the length of travel of the gases of combustion, and of a deflector leaning downwards from the firing door to throw the fresh air admitted through the latter upon the surface of the fuel also. Thus Mr. Yarrow, of the Aberdeen Railway, and Mr. Jenkins, of the Lancashire and Yorkshire Railway, simultaneously introduced the admission of air through the front along with the brick arch, while Mr. Peet, of the Carlisle Railway, and Mr. Ramsbottom adopted the deflector from the firing door, the whole combined forming a more effective smoke burning scheme than any other yet tried, and being extremely simple and inexpensive in its construction.

Mr. Sinclair, of the Great Eastern Railway, adopts the deflector over the firing door (see fig. 9); but instead of having a brick arch in front of the fire-box, he introduces two thin jets of steam on each side of the box, the object of which evidently is to mix the gases as much as possible before they enter the tubes. We do not think, however, that this scheme is as complete as the one previously described, because it does not afford the gases the increased length of travel obtained by the introduction of the brick arch.

To complete our review of the smoke burning schemes to which we have referred, we should add that each of them includes a blow-pipe, by means of which a jet of steam may be introduced into the chimney when the engine stops. This contrivance has the double effect of creating a slight draught, and of discolouring the smoke, which becomes more plentiful during these periods of slow combustion.

Before concluding our enquiry into the results produced by the combustion of coal, and in order to complete the comparison between the respective duties yielded by coal and coke we should remark that the evaporating power of the former being only two-thirds that of the latter, unless a proportionately greater amount of coal can be consumed in a given time upon the same grate area, all the engines originally designed to burn coke must be capable only of a proportionately smaller duty; and here, therefore, is another point which demands investigation.

We have thus become acquainted with the gradual growth of the knowledge on the capabilities of the boiler as an accumulator of heat or power, for it is now a well established fact that, in mechanics, these two terms are synonymous; and we have learned, so far at any rate as this knowledge at present permits, how to proportion that most important part of the locomotive engine to enable it at any time to meet a given duty. It remains now for us to glance over those questions which relate to its stability, for it should not be forgotten that the boiler is both an accumulator of power, and a reservoir of highly compressed gas, which seeks to make a way for itself wherever it can find a point too weak to resist its expansive force, when if it succeeds in so doing, from being a source of comfort and of wealth, it becomes a source of destruction and of sorrow.

It is a well-known fact that of all the structures which have to resist extraneous pressures, the arch is the lightest and the most effectual, and it is demonstrated (see *Rankine's Mechanics*) that an arch which is subject to an uniform normal pressure should be a circle; that boiler, therefore, is built correctly which is made circular, and to realise this condition should be the invariable care of the practical Engineer boiler maker. The peculiar circumstances, however, under which the locomotive boiler has to perform its work preclude the entire realisation of this condition of stability, and the universal practice now is to make the fire-box a square compartment walled round by an inner box made of copper plates on account of their greater conductibility of heat, and of their less liability to corrosion or oxidation, and of an outer box made of iron plates; a water-space of 2½ to 3½ inches is left between the two boxes, which are stayed together by means of screwed copper bolts rivetted down at the ends; at the bottom, the box is made tight by means of a ring, sometimes made of solid iron and sometimes of flanged iron; the crown of the inner box is generally flat, and stayed by a series of longitudinal bars known as the roof stay-bars, bedded accurately at each end upon the vertical walls of the box and rivetted, screwed, or bolted to the crown at suitable intervals in the whole of their length; finally, the crown of the outer box is made to follow the curve of the barrel, and generally projects some 5 inches or more beyond it; in recent practice, however, we find it to be more generally flush with the barrel, which is decidedly an improvement.

Having thus described the general design of the boiler, for the benefit of the uninitiated, the points which we shall have to inquire into are the following, viz.:—

1. What quality of iron should it be made of?
2. How should the plates be jointed?
3. How should the fire-box stays be distributed?
4. How should we proportion the strength of the roof-stay bars?

For the knowledge which we possess of these several points we are chiefly indebted to the researches of Mr. Fairbairn, a more untiring worker than whom we have not had in this important branch of physical science.

On the subject of the quality of the material, of course, there cannot be, and we believe there are not, two different opinions; it should be the best both in regard to its strength or toughness of fibre, and in regard to its ductility, for, owing to the peculiar construction of the locomotive boiler, the plates have to be flanged and worked into various shapes, especially in those portions attaching to the fire-box where iron of brittle grain, if it do not crack while it is being worked, will show its unfitness for the duty it has to perform after a very short time of service; the iron to be used, therefore, and, we believe, that generally used, is the best quality of Yorkshire iron, since the experiments made by Mr. Fairbairn, as early as 1838, show the ultimate strength of Yorkshire plate to be, on an average, 25 tons, and that of plates from other districts 21 tons only. Some experiments made by him also at the same period make the relative strength of plate joints to be as follows:—

Solid plate	100
Double rivetted joint	70
Single rivetted joint	56

And these figures have been confirmed by experiments since made at Woolwich by Mr. Bertram. This gentleman has patented a process for welding the joints of plates, and from his experiments it would appear that these joints are actually stronger than the plate itself when the weld is perfect; his process, however, has not yet found its way into general use, but the double-rivetted lap joint is now almost invariably adopted. Boiler barrels are made of plates varying from ⅜ to ½in., and the strain sustained by the plates for a given pressure in the boiler is

$$P = \frac{p \cdot D}{2240 \times 2 \times t \times 0{\cdot}7}$$

in which formula P is the strain upon the square inch of plate in tons, p the pressure of the steam in pounds per square inch, D the diameter of the barrel, and t the thickness of the plates, both in inches; from this we easily obtain also the pressure of the steam per square inch which would burst the boiler; assuming the ultimate strength of plate to be 25 tons, it stands thus

$$p_1 = \frac{25 \times 2240 \times 0{\cdot}7 \times 2 + t}{D} = 78400\ \frac{t}{D}$$

which, calculated for a boiler 4ft. diameter, with plates $\frac{1}{16}$ thick, makes p_1 = 714lbs., and, as the maximum pressure of steam seldom exceeds 150lbs., or about ¼ the bursting pressure of a barrel of large size, there is no fear of accident on the score of over pressure. Before dismissing this subject, we would call the attention of our readers to Mr. Fernie's thick-edged boiler (a longitudinal section and plan of which is shown at Fig. 10, and a full size section of one of the thick-edged plates is given below the plan of the boiler), which supplies most effectually the deficiency of strength in the joints, and the peculiar feature of which consists in making the

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plate thicker at the edges, and double rivetting the boiler at the same time. The full-sized sketch on our plate is intended to show the edge of the plate thickened to the amount of $\frac{4}{10}$, so as to bring the strength in the seams up to that in the body of the plate.

On the resistance of fire-box plates and stays, Mr. Fairbairn has made a series of direct experiments, from which we learn that with stays placed 5 inches apart the plates which were $\frac{3}{8}$ thick, began to bulge out under a pressure of 455lbs. to the inch, that is $\frac{1}{2}$ the maximum in the boiler; and with stays placed 4 inches apart they began to bulge out under a pressure of 515lbs. to the inch, or $\frac{3}{4}$ the maximum pressure, the copper plates, it should be stated, were $\frac{1}{2}$in. thick. Both experiments were pushed to the point of rupture, but, in a case like this, we have undoubtedly to deal with the question of *tightness*, since it is evident that the boiler is practically ruptured when it ceases to be tight, and which must take place whenever the plates begin to bulge out; 4in., therefore, should be the maximum distance of these stays, but it would be advisable to reduce it to 3¾in., since structures of much less importance are made to carry loads of $\frac{1}{4}$ or $\frac{1}{5}$ only their ultimate strength.

On the same ground should the roof stay bars and the bolts, or screws, which bind them and the crown of the copper box together be only 4in. apart; in practice, however, it is seldom possible to place the bars at closer distance than 4¼ or 4½in., to counterbalance which, in some measure, the distance of the bolts may be reduced a little. In proportioning the strength of a roof stay bar we should look upon it as being a beam resting freely on the two vertical walls of the box, and subject to a load uniformly distributed over its length being that due to the steam pressure upon the narrow strip of 4½in., the distance between two consecutive bars; a beam like this must satisfy to the general condition of the formula:

$$\frac{W\,l}{8} = \frac{R\,b\,d^2}{6}$$

where W is the total load in tons, l the length in inches, R the proof load of iron per square inch in tons, b and d respectively the breadth and the depth of the bar in inches. This formula applied to the present case with a maximum pressure of 150lbs. in the boiler, a proof load of 6 tons to the square inch and with the condition that the breadth of the bar shall be ¼ its depth, reads thus:

$$\frac{150 \times 4{\cdot}25 \times l^2}{2240 \times 8} = \frac{6 \times d^3}{4 \times 6} = \frac{d^3}{4}$$

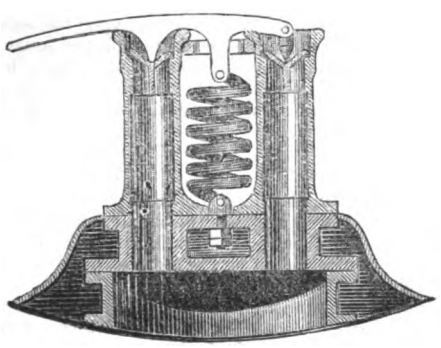
whence we obtain,

$$d = \frac{1}{2}\sqrt[3]{l^2}$$

in the application of which formula it must be remembered that the bar must have a thickness equal to ¼ its depth, deduction being made for the bolt hole.

To give the steam the means of exit when it has reached its maximum pressure, or to give the engine driver the means of releasing it whenever that may be required, the boiler should be provided with a suitable safety valve, and of these we would say that *that* one is the best which is simplest in construction, and which affords either ignorance or malevolence the least possible chance of tampering with it. Among the many schemes which have at various times been advocated, two only deserve of our special notice, because they are the only ones which have come into general use. The first is the old valve with narrow conical seat, loaded by means of Salter's spring balance acting upon the end of a lever, which is so proportioned that the balance shall indicate the pressure of steam per square inch when it blows off; this is the scheme which has been mostly patronized until now, partly as a means of ascertaining the pressure in the boiler, although its indications may scarcely ever be relied upon to within 5 or 6 pounds.

The next scheme which the annexed woodcut illustrates, is the one patented by Mr. Ramsbottom, in which the old valve is preserved, but is held in its place by the direct pressure of a strong spiral spring adjusted to release the steam at the desired maximum pressure in the boiler. The cross bar which communicates the pressure of the spring to the valves is lengthened out in order to be used as a hand lever, and the arrangement is such, that any adequate pressure applied either upwards or downwards at the end of this lever will release the steam. This, indeed, is the peculiar advantage claimed for and possessed by this safety apparatus, inasmuch as the prevalent practice of overloading the safety valve is here an impossibility. This scheme is worthy of special notice, we think, independently of its practical advantages, on account of what we may be allowed to term its elegant ingenuity.



(*To be continued*)

SCOTTISH SHIP-BUILDERS' ASSOCIATION.

ON ARMOUR-PLATING, &c.

BY Mr. Laurence Hill.

The protecting of war-ships has engaged the attention of naval men from a comparatively remote period; even the war galleys of our ancestors seem to have been protected against missiles, and to have been furnished with strong sharp bows for running down or injuring opposing vessels.

It is a curious fact, that while war missiles were comparatively feeble in effect, protection against them was deemed as necessary as it is now; whilst during a middle period, when the power of missiles had been greatly increased, it was thought hopeless to attempt any such defence.

The placing of plates at an inclination, though considered a new invention, is an old idea. In *Jamieson's Mechanical Dictionary*, published in 1827, there is a description of an invention by Louis Gompertz for protecting wooden ships with inclined plates, so as to deflect the shot, and of other plans, more ingenious than useful, for returning the enemy's shot against himself. His plan is shown at Fig. 1.

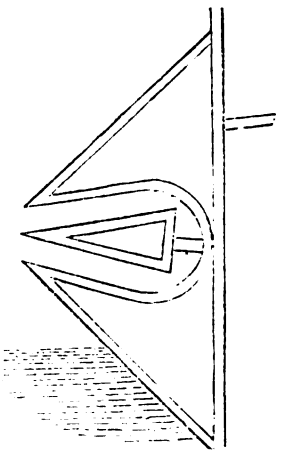


Fig. 1.

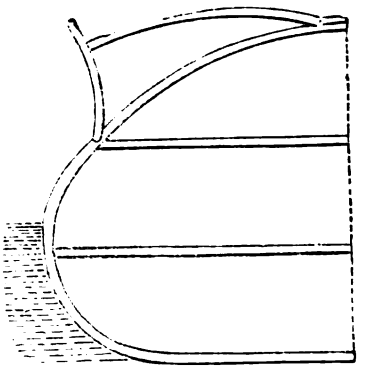


Fig. 2.

In 1836 Gompretz's invention was again brought before the public in *Herbert's Encyclopedia*. But the first time that I was aware of the principle of protection being brought before the Admiralty was in 1840, when Mr. M'Nair of Auchineen submitted his plans. In course of his correspondence with the Admiralty, Mr. M'Nair also showed the advantage of reducing the size of gun-ports—a matter now considered of much consequence.

In 1859 I submitted to the Admiralty plans for a gun-boat to be protected by plates placed at angles, both above and below the gunwale. This boat was armed with breech-loading guns, loaded from below, so as to keep the men under cover.

In 1861, Mr. Jones patented an invention for modelling war-ships, with an elliptical cross section.* Fig. 2.

Following up this invention, Captain Coles has gone very ably into the subject, advocating the advantage of *razeing* frigates, and protecting them by inclined plates.

The importance of armour plating is generally admitted; but two modes of applying it are advocated by different parties, viz., thick plates

* Mr. Jones does not patent the fixing plates at an angle, as is generally supposed.

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placed vertically, and thinner plates placed at an angle so as to deflect the shot. Each party has proved by experiments that their plan possesses advantages peculiar to itself. Both are in some measure right. For while it has been proved by experiment that plates placed at a certain angle do not afford much more resistance than vertical ones, it has also been proved that, if the angle is sufficient, much thinner plates will suffice, and it likewise appears to be ascertained that the angle must be less than 45° to be of much advantage.

When the carrying capacity is limited, or the cost of thick plates too

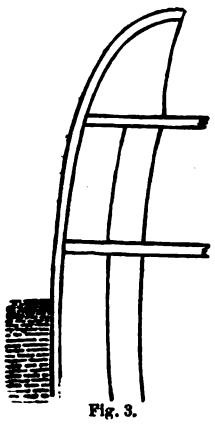

Fig. 3.

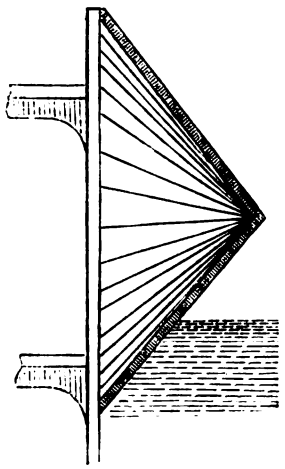

Fig. 4.

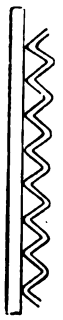

Fig. 5.

great, the thinner inclined plates may be adopted; but when otherwise, the thick plates are preferable. Both may be profitably combined in one ship. The thick vertical plates have this decided advantage, that, if strong enough to resist a point blank shot, should the heeling over of the ship present the side in an inclined direction to it, the efficiency of the protection would thereby be increased; whereas the opposite may be the case with the angled plates. Thick vertical plates have the further advantage of not encroaching on the vessel's deck space. On the other hand, the inclined plates cover a considerable portion of the ship's deck, and thus protect it from shot or shell dropping from an elevation, and also form a better protection for the men, who in small vessels, such as gun-boats, would require to remain on deck.

Fig. 6.

Fig. 7.

Fig. 8.

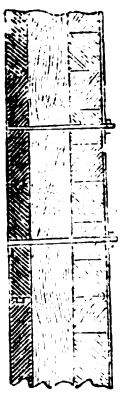

Fig. 9.

Fig. 10.

I do not think the plan of arming only the centre of the ship is good The ship may be so built and protected in that way, by cross plates, as to protect the crew and not endanger the buoyancy of the ship; but if the ends are shattered, and hang loose, the vessel is rendered useless for manœuvring, or, in fact, for any purpose except that of a floating battery.

These remarks apply to vessels intended to come to close quarters with an enemy, and withstand the effect of broadside guns. But I apprehend that much money may be saved, and much more efficient service obtained, by the employment of very fast vessels, each carrying one or two guns capable of throwing heavy shot to great distances, but unprotected, their safety consisting in their ability to keep out of danger by means of superior speed and light draught; while the same means would enable them to harass an enemy. Such vessels would be of immense service in our channels and estuaries, either against an enemy's ship of the *Warrior* class, which they could assail from places where it could not venture; or could, if judiciously manœuvred, sink any ordinary ship of war. Besides, they would be exceedingly useful as sentinel and despatch boats.

Another very efficient description of vessel would be a long flat boat, very low in the water, say of the form patented by Mr. Jones, having a deck entirely covered with moderately thick plates, and armed with a few heavy guns. Such a vessel might steam close to a heavier ship, and do considerable damage with comparatively little risk, as shot would either pass over her, or would strike the covered deck at such acute angles as to be easily deflected.

To return to the subject of armour-plates, with a view to induce such discussion as may tend to elucidate the best description and best method of application, I may remark that when sufficient money and carrying capacity are available, we may take for granted that thick vertical plates are best for protecting the sides of ships, and may also take for granted that when plates can be placed at sufficient angles, a thickness of 2 or 2½ inches would be enough for ordinary protection. In that case their cheapness would permit of their application in the simple form of common flat plates, laid along from the ship's gunwale, and supported at the proper inclination by short stanchions or knee-plates.

The plan which is recommended by Captain Coles for the conversion and protection of wooden ships is well worth consideration. But for large ships yet to be built, thick plates might be fixed vertically from a few feet below the load water-line to the level of top of port-holes on gun-deck, and above that light plates, laid at an inclination, might be fixed to the vessel's frames and deck beams, these being properly shaped for the reception of the plates. The space for working the ship would be narrowed; but as masts and rigging should be entirely dispensed with, this is of little consequence. The disadvantage of greater difficulty in boarding an enemy's vessel is got over by having light folding gangways, which would also serve the purpose of bulwarks, as shown by Mr. Jones. The elliptical shape, as suggested by Mr. Jones, has, for vessels of shallow draught, the advantages of strength and lightness of frame. Mr. Grantham proposes to curve the ship's side from water-line, increasing the curve at the bulwarks, fixing the armour to the skin without wood backing, but increasing the rigidity of ship's sides by deep brackets, as shown in diagram fig. 3.

Several plans are suggested for using the conical or corrugated form of plating.

Mr. C. Richardson proposes fixing a row of conical shields all along the ship's sides, of section represented by diagram fig. 4, and of diameter equal to distance from water-line to gunwale.

Mr. Jevons proposes a series of conical plates laid on wood backing, as represented in diagram fig. 5; but thin corrugated plates, unless the corrugations are much larger than the ball, are all a source of weakness; for if the ball impinges against both sides, the immediate effect would be to wedge out or burst the plates asunder; and in fact this kind of collision of the ball between the plates tends to strengthen the ball, by keeping its particles from falling asunder; whereas, when it hits on the point the ball has a tendency to be rent. (See fig. 6.) Whatever the form or section of the vessel may be, it is self-evident that the thicker the shield, the better the protection. A thickness of 2 or 3 inches is easily attainable, but plates of 4 or 4½ inches thick at least are required for vertical positions; and recent experiments indicate that 6 inches may be required to give confidence. The problem of how to cover the greatest number of superficial yards at the least expense, is difficult to solve. Plates such as those used in the *Warrior* and *Black Prince* (see diagram fig. 9) say 15 feet × 3 feet × 4½ inches, exclusive of the wood backing and fitting, have cost nearly £50 per ton, or about £30 per square yard covered, for the material alone. If 6½ inches thick, the expense would probably be doubled; the expense of fixing would also be increased, though not in the same proportion.

If a vessel similar to the *Warrior* is to be protected all round, there would probably be 2,000 yards of the sides and ends to be protected; this, at £50 per yard, is no less a sum than £100,000, and as the most of this expense is caused by the extra cost (chargeable as extra) for the extra weight, there is great need of finding some mode of cheapening the armour. There is difficulty in furnacing and handling masses of red-hot iron weighing 3 tons and upwards, and great waste in the manufacture, as well as necessity for very powerful machinery. But if the weights can be kept under 30 cwt., and the breadths under 18 inches, it would make a material difference, as plates, or thick bars rather, of 15 or 16 inches broad, can be rolled for £15 per ton. The weak parts in common armour-plates are undoubtedly at the edges and round the bolt-holes. If a mode of fixing is

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attainable whereby bolt-holes can be dispensed with and the edges of plates protected, a great advantage would be effected. Mr. Langley proposes and has patented a section of plate, as represented in diagram fig. 7, which protects the bolts and rivet-holes, and permits of the plates being secured to the ship's side. Mr. Robinson, of the Ebbw Vale Company, suggested a section of plate, as represented in diagram fig. 8, which does not require any bolts in the principal plates.

To combine the idea of getting rid of the bolt-holes with protecting the edges, and at the same time facilitate the renewal of injured plates, I propose a section of armour-plate or bar, and a fastening bar, as represented in diagram fig. 10, which, besides requiring no holes in the principal bars, has the further advantage of protecting the edges, these being guarded by the curved or conical form of the fastening bar. It also permits of an injured plate being taken out without disturbing any of the neighbouring plates, all that is required being to unscrew the fastening bar immediately below it, when it will drop, and be relieved from the fastening above.

It may be said that though there are no holes in the plates there are holes in the fastening bars. This, however, is remedied by the extra depth of these pieces, and their inclined and conical position.

A fastening, such as I have described, would also provide for the easy removal and replacing of a great part of the weight at the bow and stern of a ship, so as to enable it to be put in better sailing trim before setting out to a foreign station, and that the vessel might be more lively in rough weather.

Suppose a ship plated, as already described, in a fore and aft manner, to a foot or two above the water-line; but, where it is wished to have the plates moveable, let the fastening plates above the water-line be fixed vertically, then the heavier plates themselves could be fitted so as to be easily drawn up and stowed below. With suitable tackle, many tons of these bars could be drawn and lowered into the hold in a short time, and as easily re-shipped when required. Another advantage of these long bars, when placed fore and aft, is that they would add to the strength of the structure, whereas the present short plates tend to weaken it.

As to the mode of backing, I am of opinion that heavy teak backing is objectionable. It requires long bolts, and there is so much overhang in the weight carried as will soon either start or break the bolts. The same weight of iron as there is of wood would be very much more effective; for instance, a square foot of teak backing, 12 inches thick, will weigh as much as a square foot of plate 1 inch thick, and a 4-inch plate laid on teak is not so strong as a 5-inch plate without it. There is not only 25 per cent. more inertia of plate to oppose the momentum of the shot, but there is also 25 per cent. greater depth of beam, so to speak, to resist the bending or bulging of the under side, as it is evident that before the wood backing can be of any support to the plate, the plate must have already yielded by bulging, and been injured to a corresponding extent. The information derivable from experiments made by the Admiralty tends to show this; but any one may test it by an experiment on a small scale scale, as follows:—Take a rod, weighing say ¼ cwt., having one end tapered and rounded off to ⅛ inch diameter, and drop it perpendicularly down from a height on the plates to be tried. This has been tried with the following results:—When the length of fall was 33 feet, and a ⅜-inch plate lay on another plate of same thickness, the blow indented the upper plate only about $\frac{1}{24}$th part of an inch, but did not bend it. When a 4-inch teak plank was between the two plates the indentation was a full $\frac{1}{16}$th of an inch and the plate was bent ⅜ths of an inch in a length of 9 inches. When resting on pine, the indentation was about the same, but the curvature of plate was about 30 per cent. more. A square foot of teak, at recent prices, costs 10s. A square foot of plate, 1 inch thick, costs only 3s. 4d., or £9 per ton, leaving a good margin for extra weight.

Regarding bulwarks, the lighter they are the better, for the men should not be exposed on deck during action, and a light rail and netting is sufficient to protect them in working the ship, of which little should be required, as, instead of spars and a mass of rigging—all liable to be shot away, and liable to foul the screw and endanger the ship—the whole manœuvring of the ship when in action should be effected by the machinery.

I am not aware of the cost to the country for spars, sails, and rigging, nor for wages and maintaining of crews to work such vessels; but I am certain that the interest of the money which might be saved would go a long way to pay for extra coal, of which the only extra quantity required would be in moving from place to place. In action sails would not be used, and in a voyage, if time was of no moment, a reduction in speed would greatly reduce the cost of fuel. At all events, low jury masts, built telescope fashion, and capable of being easily lowered, or folded level with the deck previous to action, are what I would recommend.

To conclude, the sum of matter is, if vessels are to be protected at all, the ends require it as much as the centre. As to backing, there should be none, or only as little as is requisite to bend the plates. The bulwarks should be light, and the armour thick.

ROYAL INSTITUTION OF GREAT BRITAIN.

ON COAL.

By Warington W. Smyth, Esq., F.R.S.

The speaker commenced by proposing to select one portion only of a very large subject; and, neglecting chemical and statistical and mining particulars with reference to this important mineral, to confine himself to the physical conditions under which it is found to occur. The enormous value of the coal of this country might be understood from the simple facts that nearly 300,000 of our fellow-subjects find their employment in the coal-mines; and that the total quantity raised in 1860 amounted to no less than eighty-four millions of tons.

Mr. Smyth then proceeded to describe the nature of the various substances with which the coal is associated, referring to specimens on the table from the field of South Yorkshire. Comparison was made between the total thickness of carboniferous rocks or coal measures of different districts, as well as between the total thickness of coal (in the aggregate of the seams); and hence, it was shown, we have one reason for not estimating the value of a coal-field merely by its area, as we find it laid down in a geological map. Thus, the well-known Durham field, with a thickness of measures of about 2000 feet, has a total thickness of coal of 50 feet. The Derbyshire, 2000, and almost twice the thickness of coal; the North Staffordshire, 6000 feet of measures, and 130 of coal; whilst the South Welsh and Saarbrücken fields exhibit thicknesses of 12 to 15,000 feet, with a proportionate increase (especially in the latter) of coal.

A second reason for mistrusting area as a criterion of the importance of a coal-district, is the various forms into which the coal measures have been thrown or moulded by agencies operating at a later date in the earth's crust, whence some districts may exhibit by outcrops an indication of the full amount of their entire contents, whilst in others the beds pass with a gradual inclination beneath newer formations, through which they may nevertheless be accessible. As instances of this were quoted, the vast accession of mineral wealth added, even in the last twelve years, to the Westphalian coal-field, by the explorations carried out through the covering of cretaceous rocks which clothe the northern side of the coal-field, and the remarkable pit lately completed by the Duke of Newcastle, at Shireoak, which, commenced at a distance of several miles from any visible coal-measures, pierced the new red sandstone and magnesian limestone, and reached the "top-hard" coal at 515 yards in depth.

Mr. Smyth then described certain physical features produced in the coal seams subsequently to their consolidation, such as the *cleat* and *backs*, or various nearly vertical divisions, often more or less filled with carbonate of lime or iron pyrites, which add greatly to the amount of ash and clinker.

In referring afterwards to the principal families of plants which are found either in, or associated with, the coal, he wished to show that their occurrence throws a light on the origin of the coal-seams, which again becomes an important guide in enabling us to judge of the continuity of various fields, a question fraught with vital importance, in consequence of the rapid rate at which some of them are being exhausted. Thus the position of the stigmaria in the under-clay or floor of the seam, and of the stems of sigillaria, lepidodendron, calamites, &c., in the roof strata, point to the probability of the growth of the vegetable matter *in situ*. The existence of numerous upright stems, and especially those occurring so often and so dangerously to the miners in the roof of certain coals, is a strong confirmation of the gradual depression of the tract in which these plants grew; and Göppert has shown that the careful examination of a number of seams proves the existence in the coal itself of every family of plant which has been met with in the coal measures.

Thus much had referred to the true carboniferous period, in which it is commonly supposed that a vigorous vegetation first arose, but the speaker described his finding, a few months since, in the Laxey lead and copper mine, in the Isle of Man, at 120 fathoms deep, a seam of anthracite coal, three or four inches thick, in the midst of ancient schists, probably Lower Silurian. He then referred to coaly and lignitic beds in newer formations, and more particularly to the tertiary brown-coal, which in continental, and especially in Southern Europe, attains to great importance. The excellent preservation of the vegetable remains in the lignite, has enabled Unger and Heer to make accurate comparison with existing floras, and to show that the tertiary flora had nothing in common with our present flora in Europe, but an extraordinary resemblance to that of modern North America. This was especially to be noticed in closely similar species of the genera *Liquidambar*, *Liriodendron*, *Pavia*, *Nyssa*, *Robinia*, *Taxodium*, *Sequoia*, *Juglans*, *Glycyrrhiza*, *Cercis*, *Laurus*, *Rhododendron*, *Cissus*, and certain oaks and pines. There was hence no retreating from the conclusion, that at this portion of the tertiary period a land communication must have existed between America and Europe. Fragments of that land, with

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relics of the same tertiary flora, still exist in Iceland and the Azores, with their *surturbrand* and lignites; and thus, that Atlantis, which is generally set down as a dream of the poets, is brought again into solid existence by the studies of the geologist. A relation of this kind at a comparatively recent period, throws a light on the causes of phenomena belonging to an earlier epoch, and will enable us to form conclusions, if not upon the absolute contemporaneity of certain beds or groups of coal measures, at all events upon the physical connection within a given period of the agencies which were forming coal not only in the various fields of Europe, but also in North America: and the speaker concluded by pointing out that the reasoning on the continuity among one another of our British coal-fields, or of them with those of Belgium and North France, depends on somewhat complex data, which scientific investigation can alone afford.

SPECIMENS OF COAL AND SHALE FROM STRAFFORD COLLIERIES.

No.	Order of Minerals from Surface.	Thickness.			Depth below Surface at Strafford Colliery.
		Yds.	Ft.	In.	Yards.
1	Black Shale above Joan Coal	5	2	3	
2	Joan Coal	...	1	8	30½
3	Bottom of Joan Coal	...	...	...	
4	Spavin—Floor of Joan Coal	...	2	0	
5	Black Rust	1	0	0	44¾
6	Shale—Roof of Flockton Coal	...	...	6	
7	Shale—Top of Flockton Coal	...	2	5	53½
8	Spavin—Floor of Flockton Coal	...	2	8	
9	Roof of Channel—Bastard Shale	...	...	8	
10	Top of Channel Coal	...	1	7	84
11	Coal and Spavin	...	1	2	86
12	Black Spavin	...	1	2	86yds. 1ft. 2in.
12*a*	Cank Stone	...	...	...	103
13	Shale 3 ft. above Fenton Coal				
13*a*	Shale 2 ft. above Fenton Coal				
14	Shale 14 in. above Fenton Coal	...	...	...	
15	Spavin—Roof of Fenton Coal	1	0	4	107
16	Fenton Coal (top)	1	0	0	
17	Roof of Parkgate Coal	...	...	...	
18	Shale at top of Parkgate Coal	...	...	...	
19	Top part of ditto	0	2	7	
20	Bottom part of Parkgate, Top Bed	...	...	...	131½
21	Spavin—Middle of ditto	...	1	0	
22	Parkgate bottom bed	...	1	3	
23	Black Bind	...	1	7	216¼
24	Ironstone—"Silkstone Black Mine"	2	...	...	
25	Coal—"Black Mine"	...	...	5	220
26	Stone Bind—top of Silkstone	9	0	4	
27	Brass Band and top of Silkstone Coal	...	...	...	
28	Top part of ditto	...	2	11½	
29	Dirt from middle of ditto	...	...	4	234
30	Bottom Bed—Silkstone	...	2	7½	
31	Stone Bind—Floor of ditto	...	...	...	

INSTITUTION OF CIVIL ENGINEERS.

Nov. 11, 1862—JOHN R. M'LEAN, ESQ., VICE-PRESIDENT, in the chair.

Before commencing the business of the evening on this, the first meeting of the session, and in the absence of the president, the chairman said it was his duty to notice the loss the institution had sustained by the death, during the recess, of two of its most eminent members, Mr. John Edward Errington, vice-president; and Mr. James Walker, past president.

For upwards of thirty years, and indeed ever since the introduction of the railway system, Mr. Errington occupied a prominent position as an engineer, and, in conjunction with Mr. Locke, executed some of the principal railway works in Great Britain. He was, like his partner, Mr. Locke, a strong advocate for economy in the first cost of construction. By his death the profession had lost one of its most distinguished members, the institution one of its warmest supporters, and many of us a sincere friend, and one ever ready to afford advice, especially to his numerous pupils and assistants, whose interests it was his constant endeavour to advance. As many of his pupils were actively engaged in the practice of the profession, and had, through his influence, been enabled already to take good positions, the chairman expressed the hope that they would feel it a duty, no less than a pleasure, incumbent upon them, to communicate plans and descriptions of the works of their eminent masters, and so keep alive the memory of "Locke and Errington" in the Institution of Civil Engineers. Mr. Errington had proved his attachment to the institution, and his desire to see it prosper, by bequeathing to it the sum of £1000, free of legacy duty, and without attaching any condition whatever to the gift.

Mr. Walker was one of the oldest members of the profession, having been in active practice as an engineer for upwards of sixty years. He was also one of the earliest members of the institution, having joined it in the year 1823, and, after the death of Mr. Telford, became its president. For a period of eleven years, during which he so ably conducted its proceedings in that capacity, he was most devoted to its interests, and to his zeal and energy must be greatly attributed the eminent position it held on his retiring from the chair in 1845. Mr. Walker's name was associated with many of the greatest hydraulic works in England and Scotland, including lighthouses, harbours, bridges, embankments, and drainage. His opinion was much valued by the elder brethren of the Trinity House, by the Lords of the Admiralty, and by the Corporation of the City of London, and it must not be forgotten, especially at the present moment, that twenty years ago he laid down lines for embanking each side of the River Thames, which have never been improved. As the chairman had had the privilege of being in Mr. Walker's employment for many years prior to 1844, he had an opportunity of knowing his worth, and must express his gratitude for many acts of kindness, and state that it was Mr. Walker's constant endeavour to promote the interests of himself and others. Many members of the profession had also been trained in the same school, including Burges, Bidder, Hawkshaw, Borthwick, and Hartley. During his long and useful career he had secured the admiration and respect of numerous influential friends, as well as the regard of his professional brethren.

The chairman had much gratification in announcing that Mr. Walker having left at Mr. Burges' disposal the twenty-five remaining copies of "Telford's Life and Works," as well as the copyright and the copper-plates, Mr. Burges had, in the most handsome and liberal manner, presented them to the institution.

ON THE RAILWAY SYSTEM OF GERMANY.

BY MR. ROBERT CRAWFORD, ASSOC. INST. C.E.

It was stated that in Germany, as in England, tramways had formed the germ from which subsequent enterprise developed the vast network of railways now extending throughout the length and breadth of the land. The oldest of these undertakings originated in a fifty years' "privilege," granted by the Austrian Government upon the 7th of September, 1824, for the construction of a line from Budweiss, in Bohemia, to opposite Linz, on the Danube—a distance of upwards of 80 English miles. Subsequently, a concession was obtained for a line from Linz to Gmünden, 42¼ miles. The cost of the Budweiss, Linz, and Gmünden line was about £4877 per mile. The gauge was 3 feet 7½ inches, and it was worked by horses until 1854, when small locomotive engines were employed, first upon a portion of the line, and in the following year upon the entire length.

A proposal to adopt steam as a motive power, instead of horse labour, was carried into effect for the first time in Germany in the case of a railway, 4 miles in length, from Nüremberg to Fürth, which was opened for public traffic on the 7th of December, 1835. Thus Germany, possessing at the close of the year 1835 upwards of 108 miles of tramways, had up to the same time only 4 miles of railway properly so called. In the five following years railways were introduced into all parts of the country, so that at the close of 1840 there were twelve railways, either wholly or in part finished, with a total length opened of 377 miles. In the next ten years this had been increased to 4,487 miles; by the close of 1860 to 8,512 miles; and at the end of 1861 a total of 8,866 miles had been constructed, at an average cost of £16,400 per mile. Nearly one-fourth of the entire length was provided with double lines of rails. About 38 per cent. of the existing lines was Government property; 10½ per cent. the property of companies,

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applied after the engine had run its first 46,109 miles, and subsequently worked by Government; and 51½ per cent. the property of, and worked by private or joint-stock companies. Further, it appeared that 39¼ per cent. of the entire length was constructed by the different States; 24¾ by companies under a guarantee of interest, or a Government subvention; and 35¾ per cent. by companies at their own cost and risk; so that Government aid had been granted, directly or indirectly, to nearly two-thirds of the entire system. These 8866 miles of railway comprised 62 different undertakings, as at present constituted, under as many different organisations, and were managed by 19 Government departments and 43 boards of directors.

At the close of the year 1861 Germany had, in addition to the railways, about 143 miles of tramways, constructed at an average cost of £3200 per mile.

With a view of establishing a common plan of action, and of regulating to a certain extent the relations of the different railway companies with each other, a society was formed in the year 1847 under the title of "The Association of Government Railway Directions," which now embraced the whole of the lines with very unimportant exceptions. Each company subscribed a fixed sum towards the general management fund, together with a variable amount depending upon its length, and was represented at the meetings of the association and in the debates in proportion to its importance. A code of laws had been drawn up and agreed to, which was revised from time to time, the rules expressing the decided opinion of the associated body upon all points usually involved in the construction and working of railways. The gauge was now universally throughout the country 4 feet 8½ inches. With regard to curves and gradients the rules laid down were—First, the radius of curvature should, if possible, not be less than 3600 feet in level land, nor than 2000 feet in hilly districts, except in particular instances, where it might be necessary to reduce it to 1200 feet, or even in very rare cases to 600 feet, but never less. Second, the general scale of maximum gradients admissible on railways was 1 in 200 in level districts, 1 in 100 among hills, and 1 in 40 on mountain lines. Several examples of sharp curves upon works already executed were then noticed. The increased power of locomotive engines had led to a severer character of ruling gradients being introduced than was formermy contemplated, and there were ample proofs in every part of the country, that the limits recognised at present as suitable for the working of locomotives had been reached. Many instances were then given of steep gradients and sharp curves, including a particular account of the Semmering railway, and of the mode of working it. As, however, a description of this railway had been brought before the Institution by Mr. C. R. Drysdale, in the year 1856 (Minutes of Proceedings Inst. C.E., Vol. xv., p. 349), it would suffice to say, that the experience derived from the working of the line went to show, that one of the goods' engines was capable of drawing up the inclines of 1 in 40, at the rate of 9½ miles per hour, a train whose gross weight varied from 100 to 165 tons, according to the state of the rails and of the weather at the time. The ordinary rate of speed was fixed at—

	Ascending. Miles per hour.	Descending. Miles per hour.
For express trains . .	14½	16½
„ ordinary passenger .	11¾	14½
„ goods, including military transport . .	9½	9½

The maximum number of trains which had passed over the line in one day was 72, counting both ways. This was during the Italian war. The ordinary number was 27, with from seven to eight carriages each. The line was about 27½ miles in length, was laid with a double way throughout, and had cost £98,270 per mile.

It appeared to be a general, although not a universal plan, in the case of all main lines, to prepare the earthworks and masonry for a double way throughout, but not to lay the second line of rails until the success of the undertaking and the requirements of the traffic demanded it. Some of the heaviest earthworks executed up to the present day were then alluded to, including one on the Southern State Railway of Bavaria, the greatest height of which was 172 feet, and which contained nearly 3,000,300 cupic yards of material. A list of the largest tunnels on the principal lines was next given.

Viaducts and bridges were treated under two headings:—first, bridges composed altogether of masonry, and second, iron bridges. The views of the Associated Railway Directions on bridge building were,—1st. For bridges, arches of stone or good bricks were preferable to every other description of structure, except in cases which required very oblique bridges. 2nd, Timber bridges were inadmissible. 3rd, When iron bridges were made use of, the portion of the structure which sustained the roadway should consist either of wrought or rolled iron. Thus cast-iron bridges as well as timber ones were removed from the field of investigation, the former by negation, and the latter by direct condemnation.

Instances were then adduced and details given of several examples of stone viaducts and bridges of imposing dimensions and extent, including those over the Goeltzsch and the Elser Valleys, on the railway from Leipzig to Hof,—and the Neisse Viaduct on the railway from Kohlfurth to Goerlitz, in Prussia. The result of a series of experiments, for the purpose of ascertaining the best description of concrete to be placed round the foundations of the river piers in the latter case, give the proportions most suitable for yielding a quick setting, hard concrete at 22 per cent. of cement, 22 of sand, and 56 of small broken stones, not exceeding 2 inches diameter. In regard to the bridge over the River Neckar, on the railway from Frankfort-on-Maine to Heidelberg, it was stated that the depth of the keystone was somewhat over the minimum required both by Desjardin's formula and by that of Gauthey; but on the other hand it was so out of proportion with the huge thickness obtained from the method of Perronet, as to prove the total unfitness of this system for calculating cases similar to the one in question. Thus the

	Metres.
Neckar Bridge as actually built had a depth of	1·200
„ according to Gauthey's formula it required . .	1·125
„ „ Desjardin's „	1·140
„ „ Perronet „	3·241

In the case of wrought iron bridges the arrangement most usually adopted, when the spans were wide, was that of a lattice construction in some one of its various modifications. One of the earliest examples which was described in detail, was the bridge over the river Kinzig, at Offenburg, on the Baden State railway, in which it was considered that the arrangement of the material was not judicious, as,—1st, The dimensions of the ironwork were uniform throughout the length of the span. 2nd, Although a stronger lattice construction was adopted in the case of the central girder, still the top and bottom sections were of similar dimensions to the outside ones; and 3rd, The cross sectional area of the iron had not been properly proportioned to its different powers to resist compression and extension, where those forces acted. The bridge over the river Vistula, at Dirschau, on the Eastern railway of Prussia was next referred to. It consisted of six spans, each 397 feet 6 inches in the clear, the depth of the girders being 38 feet 9 inches, and the whole of the material in the superstructure being carefully proportioned to the nature of the strains to which it would be exposed.* The Marienberg bridge over the river Nogat, on the same railway, was likewise minutely described. The next examples selected were those over the Rhine, at Cologne and at Kehl, close to Strasburg; in the latter case the method adopted in constructing the foundations progressed at the rate of about 20 inches per day of twenty-four hours.

In addition there was also another bridge over the Rhine at Mayence, which consisted of thirty-two openings, having together a clear waterway of 3,134 feet 6 inches lineal measure. The ironwork in the superstructure was somewhat similarly arranged to that of the Saltash bridge, modified in some particulars as to the cross section and the form in which the material was applied, according to what was known in Germany as the system of Professor Pauli, of Munich, which gave a rectangular top to the beam instead of an oval one.†

Attention was then directed to the Permanent Way. It appeared that about seven-eighths of the rails in use were of the broad base, or contractor's pattern; the remaining one-eighth being composed chiefly of chair rails, with a small proportion of bridge-shaped ones. As to size, the rails were not less than 4½ inches in height by 2¼ inches width of head, and the surface was curved to a radius of from 5 to 7 inches. They weighed generally from 66 to 76 lbs. per yard. Fish-plates were now almost universally adopted for connecting the ends of the rails, and the joints were always supported ty a sleeper; a wrought-iron chair being interposed between the rail and the timber. Recently, a trial had been made of the modern English system of leaving the joint free without any sleeper under it. The almost universal system of supports was that of cross-sleepers. They were of oak, where it could be procured at a reasonable price; but different descripttons of larch and fir were often used after being prepared by some chemical process to resist the tendency to decay.

The quantity and description of rolling stock in use on different railways in Northern and Southern Germany varied greatly; but as nearly as could be estimated at the close of the year 1861 there were

Locomotive engines	0·414 per English mile.
Passenger carriages, average 41·8 seats each .	0·807 „
Goods trucks, average lead 6·9 tons . .	7·040 „

Before any engine was permitted to be used, its boiler must be tested with hydraulic pressure to at least one-and-a-half times the maximum steam pressure which it was intended to sustain, and a similar test must be

* For further detailed particulars and illustrations of this bridge, *vide* Artizan Exhibition Supplement, No. 2, August, 1862.

† A full description and illustrations of this bridge will be found in No. 1, Artizan Exhibition Supplement, July 15th, 1862.

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repeated every time an additional 36,887 miles had been made. The rate of speed was usually, for express trains, from 27 to 35 miles an hour, for ordinary passenger trains from 20 to 25 miles, and goods trains from 10 to 15 miles per hour, in each case exclusive of stoppages.

Nov. 18, 1862.

In the discussion upon Mr. Crawford's paper on "The Railway System of Germany," it was observed that the paper contained an interesting description of various railway structures rather than treated of the German system of railways. The German system of construction was, in general, no more than adopting, in a greater or less degree, the plans which had been found successful in this country, with such modifications as the circumstances required; but their works would not, as a rule, bear comparison with those in England. For instance, the viaducts built from the designs of Mr. J. Miller, M. Inst. C.E., upon the Glasgow and Dumfries Railway, were still unequalled in Europe for boldness of conception and excellence of workmanship, and in Lancashire there were viaducts 100 feet in height, and in other places 150 feet in height; and in all these cases, instead of consisting of tier upon tier of arches, as was the practice on the Continent, there was only one tier of arches. With regard to the Dirschau and the Marienberg bridges, their mathematical construction had been admitted to be faulty, there being a want of due proportion between the several parts, and their cost had certainly not been less than £45 per ton.

One of the most remarkable examples of engineering on the Continent had not been noticed. This was the line from Cologne to the Prussian frontier, between Verviers and Liege. It was constructed at an early period in the history of railways, abounded in rapid curves, and comprised an extraordinary series of tunnels and viaducts.

When Mr. Vignoles, thirty years ago, laid out the railway from Brunswick to the foot of the Hartz Mountains, he introduced what was termed in this country the "Contractor's Rail," but what was better known in America and all over the Continent as the "Vignoles' Rail." At the same time, he strongly advocated the plan of fishing the joints first adopted in Germany.

The great principles which characterised the German system of railways were the simplification of the permanent way and the perfection of their statistics. All the companies were compelled, as in France, to give positive returns, under specific heads, of every detail of expenditure, and as these were published annually, the companies were brought into a wholesome competition for the reduction of the working expenses to a minimum. A recent inquiry showed that the expenses per train mile on two-thirds of all the German railways were within a fraction of each other. Although it would be advantageous to follow the same plan in this country, as by tracing every item of expenditure to its source it would readily be seen where economy could be effected, yet it was believed that the average expenses per train mile were less in Great Britain than in Germany, or indeed on the Continent generally. Late returns showed that on the Semmering Railway the working expenses exceeded the receipts, so that however advantageous that railway was to the Austrian Government, it was unprofitable as a speculation. The absence of preliminary and parliamentary expenses, and the possibility of obtaining land at its mere agricultural or town value, instead of paying an exorbitant price for it, led to economy in first cost. But, on the other hand, in no part of the world could work be done so cheaply as in England, whether measurement or weight of material were taken as the standard of comparison.

It was believed that, owing to the small cost, comparatively, per mile, due to the causes which had been mentioned, and to the absence of competition, arising possibly from the fact that Government had contributed aid, either directly or indirectly, to two-thirds of the entire system, German railways were destined to pay a remunerative interest to their shareholders. Until quite lately, Parliamentary Committees in this country appeared to consider that unlimited competition was beneficial; but experience had now proved that it was not desirable for the public, and certainly not for the shareholders. It was admitted that statistical returns were invaluable to Railway Companies, as enabling the directors and officers to trace the cost of each individual part of their system, it might be through a series of years, and thus at once detect any excess of expenditure. But the utility of the publication of such returns was very questionable, as it was impossible fairly to contrast the details of the cost of one system with those of another, without being fully acquainted with all the circumstances affecting the cost in each case. For instance, on some portions of the North Eastern Railway, the expenditure per mile amounted to nearly 80 per cent. of the receipts, whereas on others it did not exceed a minimum of 40 per cent. Within any particular system, where all the facts were known, such comparisons could be properly made, but as between two different companies, where the conditions were dissimilar, they would be worse than useless, as being calculated to mislead those who placed reliance on them. It was mentioned that comparative statements, prepared with great ability from exactly the same data, of the working expenses of the two companies resulted in deductions being drawn exactly the reverse of the facts. The rules of "The Association of Government Railway Directions," as to gradients and curves, were commented upon, as practically amounting to nothing; and the condemnation of the use of cast iron for bridges seemed to be without sufficient reason, as there were many admirable examples of the use of that material for railway bridges.

It was remarked that, some years ago a curve of seven chains radius had been laid down on a line in this country, and the trains were calculated to, and did run round it at the rate of 25 miles an hour; and if circumstances required it, there was no reason why curves of 300 feet radius should not be adopted. With regard to gradients, particular districts seemed fitted for certain inclinations: thus, for instance, in the West of England 1 in 70 or 1 in 80, and in other places 1 in 100, only could be obtained, except at a greatly increased outlay. The speed on German railways appeared to be lower than was necessary. On the Semmering Railway the express trains were limited to 14 miles an hour both in ascending and descending gradients of 1 in 40. It was asserted that this speed might be doubled with safety, and that the cost of working up the Lickey incline at 28 miles an hour was not greater than at 15 miles an hour. From 1840 to 1845, the speed on that incline was 15 miles an hour with passenger trains of seven or eight carriages; whilst from 1845 to 1855, owing to an increase of traffic, the trains were composed of from ten to twelve carriages, and they were conveyed up the incline, at from 28 to 30 miles an hour, at no greater practical cost.

It was observed that, so far back as the year 1848, the German governments had taken to the belief, that a special education for engineers of all classes—mechanical and civil—was one of the first duties of a government. At that time there were regular colleges for the training of skilled workmen, and for the education of civil engineers, in most of the great cities of Germany. By these means a set of thoroughly educated young men was prepared, ready to acquire practical knowledge and to turn it to account, in a very short period of time. One result of this system had been, that whereas English locomotive engines were at first copied implicitly, the German engineers gradually took to making the designs for themselves, and to depart more and more from the established patterns, so that now, on most of the principal lines, the engines were made exclusively in Germany, in some cases at a less cost than in this country, and it was said that a Berlin firm had recently tendered successfully for locomotive engines required in England.

In regard to management and economy of working, it was maintained that the public convenience was less consulted on German railways than on English lines; there were fewer trains, the speed was very much slower, and the stations were further apart. The rate of fares in Germany had not been stated, but it was believed that for the transport of goods and minerals the charges were higher. These were elements why larger dividends were realised on comparatively smaller capitals.

To this it was replied that in Westphalia, the centre of German industry, as many trains ran as on some English lines, and the speed of the express trains was 40 miles an hour.

With respect to the construction of German railways, it was believed that the earliest lines in Germany were offshoots from the schools of mines in that country; and though they had no doubt taken the first ideas of railways from their great projector, George Stephenson, yet they had been carried out by themselves; and that the earliest example of an iron lattice bridge was that across the Elbe at Magdeburgh, the wooden lattice having been previously adopted in America.

The growing prominence of Germany in the industrial arts was attributed mainly to the system of technical education, particularly of engineers, which prevailed there; and it was argued that the distance between the English and German engineers was an increasing one in favour of the latter, as was deemed to be evidenced by the superior character of the continental machinery in the International Exhibition.

One of the reasons why German railways had been executed so cheaply was attributed to the population supplying an excellent industrious class, and to the works not being pushed forward so hurriedly, by which the price of labour was artificially raised. Throughout Prussia the cost of the earthworks did not exceed from 8*d*. to 9*d*. per cubic yard, the German navvy receiving only 1*s*. 6*d*. per day. Very little plant was employed, the barrow runs were longer, and the embankments were chiefly executed in that way, instead of by tipping from waggons from a great height, which might account for their assumed superiority.

In conclusion it was submitted, that without venturing to depreciate that which was a valuable adjunct to practical men of all classes, yet undue importance must not be attached to mere technical education, in contradistinction to that practical knowledge which it was essential the engineer should bring to bear in the exercise of his profession. The history of engineering showed that the works which reflected the highest honour on this country had been carried out by men who had not received a special education, but who, being possessed of great natural genius, were enabled to take advantage of the national resources and peculiarities in such a way as to bring the profession to the high pitch it had already attained, and to command for English engineers universal respect.

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ON THE UTILIZATION OF PEAT, WITH REFERENCE MORE PARTICULARLY TO THE MANUFACTURE OF HYDRO-CARBON OILS.*

By B. H. Paul, Ph. D.

The application of peat to some useful purpose, is a subject which has, at various times, attracted considerable attention; a vast amount of inventive ingenuity has been bestowed upon it; it has given rise to very sanguine, and I may say, in some cases, very aggravated expectations, and as a natural consequence it has been a source of proportionate disappointment. Notwithstanding the numerous attempts and proposals that have been made for utilizing peat, very little has been done as to inquiring into and elucidating what are really its capabilities and disabilities as a material for use in the arts. But a knowledge of these circumstances is an essential preliminary to any successful application of it, and I hope to be able, in some degree, to contribute to the acquisition of such a knowledge by bringing before this Society the results of several years' practical experience in the prosecution of this subject.

Taking for granted that the existence of enormous deposits of peat in various parts of the kingdom is sufficiently well known, and having regard more especially to its technical value, it will be unnecessary for me to enter into any consideration of the origin and formation of peat, or of the different views entertained on that subject. It will be sufficient for my purpose to consider peat as it exists now; and with regard to this point there are two modes in which it occurs, which I believe to be of importance as regards its application to useful purposes. In one case we find peat deposits in the form of what are called peat-bogs, masses of peat of considerable superficial extent, and generally of great depth, 20, 30, and sometimes upwards of 100 feet deep, where the uppermost layers are of a loose, fibrous, or greasy texture, and saturated with water to such an extent, in some instances, as to be incapable of affording any support to the foot. When the water is drawn off from these bogs by drainage, the peat is generally found to vary in character according to the depth at which it is situated, gradually becoming darker in colour, more compact, and having less evident indications of vegetable structure. At the bottom of such bogs, the peat is generally a black mass, of a clayey consistency.

In the other case, we find, situated on the slopes of mountainous country, peat deposits, which are never of very great depth, generally from 12 to 2 feet, and where the peat is sufficiently solid to be walked upon with ease. In these deposits the peat is of a more uniform texture and character throughout, than in bogs, although there is always a greater or less difference between the peat at the surface and that at the bottom. These deposits of mountain peat are very common in the Highlands of Scotland and in some parts of Ireland.

Mountain peat offers very much greater facilities for cutting than bog peat, and it is generally of much better quality. Bog peat, when dried, has very much the appearance of pressed hay; it rarely has a density of more than 300 or 400 —water being 1000,—and the cubic foot weighs only from 15 to 30 pounds; it would perhaps be useful to distinguish it by the term turf, from the true mountain peat, which when dried is dark brown or quite black, with little or no remains of plants in it; capable of taking a high polish when rubbed, and of a density greater than that of water, the cubic foot weighing from 53 to 78 pounds.

The method of cutting peat in the Highlands of Scotland is very different from that adopted for cutting peat from bogs. In the first place trenches are opened at distances of about ten yards apart; and, according to the nature of the ground, these trenches are made from 50 to 400 or 500 yards long. After removing the surface sod at the places where the trenches are to be cut, for a width of three feet, along the whole line of the trench, the peat cutter digs out the peat with a peculiar-shaped tool, in slices of about a foot square and three or four inches thick. As fast as these slices are cut, another man takes them off the peat iron and throws them on the surface, so as to spread them out as much as possible. In this way prisms of peat, measuring three feet in width and depth are cut out at intervals of ten yards, and the number of slices cut in each trench are just as many as a man can throw on both sides of the trench without shifting his position except from one end of the trench to the other as the cutting advances.

In succeeding years the peat is cut from the two banks thus formed in each trench, to a width of only 18 inches and a depth of three feet. The advantage of this system of cutting is that there is no necessity for removing the peat by barrows to the spreading-ground, a proceeding which is attended with considerable expense for labour. When the peat is cut in this way from a bank 150 yards long, it, will give 75 cubic yards of wet peat, and the number of slices into which this is divided will be about 8000. Then as the banks are ten yards apart, there are five yards width of drying ground to each bank, or a superficial area of 6750 square feet to each bank of 150 yards long. Cutting it in this way every year, it would take ten years to remove the whole of the peat to a depth of three feet. As the banks are cut away in successive years, the area of spreading-ground on the surface is reduced, and some of the peat has to be spread at the bottom of the trench, the area of which increases as that of the banks' surface is reduced by the cutting.

The peat, cut to a width of 18 inches and a depth of three feet, from a bank of 150 yards long, is what is called an iron's work, and the 75 yards of peat so cut yields about ten tons of dry peat, so that to cut seven or eight thousand tons of dry peat would require 750 irons' work, or banks about 64 miles in length, and extending over an area of about one-fifth of a square mile. This area of ground would supply seven or eight thousand tons every year for ten years.

The cutting and spreading of peat in this way forms but a proportion of the cost of the dry peat. A far more considerable portion of its cost results from the labour of collecting the dry peat and bringing it to the place where it is to be used. Herein lies one of the greatest difficulties of employing peat on any very extensive scale. Whatever mode may be adopted for collecting the dried peat to one spot for use, the cost of carriage will increase in proportion to the increase in the quantity of peat consumed at that spot. Thus, for instance, in the case of a factory consuming 7000 tons annually, it would be requisite to carry the peat, on the average, a distance of one-tenth of a mile; if the quantity consumed were 70,000 tons, it would be requite to carry it an average distance of half a mile, and if the quantity consumed were 300,000 tons a year, it would have to be carried an average distance of two miles, or a mile and a half, inasmuch as the cutting-ground would extend over an area of eight square miles.

The extent to which this advantage affects any particular instance of the use of peat will depend very much on the skill exercised in laying out the ground for cutting the peat and disposing the banks and tram-roads, or other means for conveying the peat to the place where it is to be used; but it is a disadvantage which can only be reduced by such means within the smallest possible limits, and which is quite inseparable from the use of peat on a large scale.

Another prominent difficulty attending the use of peat consists in obtaining it in a dry state, fit for use as fuel or otherwise. Mountain peat, as it occurs naturally, contains as much as 80 per cent. of water, even when it has been well drained, and bog peat often contains very much more. Consequently, to obtain one ton of dry peat, five tons of material have to be dug and spread, and four tons of water have to be got rid of by evaporation. When mountain peat is cut in slices, as I have decribed, and spread out on the ground during dry weather, the drying goes on rapidly, the surface of the pieces acquire a kind of skin, which is not wetted again by rain, and the peat, in the course of a week, is sufficiently hardened to be handled; the pieces are then set up on edge, so that the air may play on both sides, and in the course of six weeks or two months, they are dry enough to be stacked or heaped up. But, unfortunately, peat districts are generally remarkable for a very moist atmosphere and for a great frequency of rain. In the Highlands of Scotland and in the Hebrides on the average there is rain four days out of six, and it is only during the months of May, June, and July that you can expect to have any continuance of weather favourable for drying peat. It is necessary, therefore, to obtain the utmost advantage of that period for the drying of the peat, and to do so, the peat must all be cut before the end of May at latest. On the other hand, if the peat is cut in frosty weather, and becomes frozen, it crumbles to powder when the thaw comes, and for this reason it is not safe to commence the cutting at all before April or even May. As a rule it might be said that the month of May is the only time available for cutting peat in the Highlands of Scotland, and more especially in the Hebrides, so as, on the one hand, to avoid the destruction of the peat by frost, and on the other hand to ensure the best possible chance of getting it well dried.

Notwithstanding the general moist condition of the air in those places, the boisterous winds which prevail are very efficacious in drying the peat; and if, during the month of May and early part of June the peat has got a certain amount of drying, and a skin has formed on the surface of the pieces, it may be considered safe, whatever kind of weather there may be afterwards. It may then remain on the ground, set up in little heaps, till the autumn, and will get the advantage of whatever dry weather there may be. Of course, even in this case, the quality of the peat will depend on the weather; but if the cutting is not finished by the end of May, there is always less probability of getting the peat in good condition.

It will be evident from these circumstances that the cutting of peat to supply a factory consuming any large quantity, must be an affair requiring considerable management, so as to get the work done in the short space of time available for it, and the difficulty of effecting this increases in proportion to the quantity of peat required to be procured.

Two men working together, one cutting and the other casting the peat, will, in good weather, get through about one iron's work in a day, equivalent to 10 tons of dry peat, so that if they were able to work every day during May, they would cut from 200 to 300 tons of peat; and to get 10,000 tons cut and spread, 100 men would be required for the whole month; and to get 300,000 tons cut and spread would require 3000 men to be employed for the whole month. It is unnecessary to dilate upon the difficulty of getting such a large number of men together for the work, and of organising a system for measuring the work done, and carrying on the general supervision of the peat-cutting on such a large scale; but I may mention that there are circumstances connected with the habits of the people in these districts, which are in some degree favourable to the carrying out of such an operation. The people are almost all fishermen, and the fishing season does not commence until the end of May or June, so that it would be possible to obtain many of these men before they go to the fishing, and thus the inconvenience of employing a large number of men for a short period would not be so great there as it would in most other instances. Moreover, these people are accustomed to hutting themselves with no small degree of comfort, in huts or bothies built of the surface sods of the peat, and they live in these, as a rule, throughout the Hebrides; so that a squad of 200 or 300 men find, on the ground where they are going to work, the materials for their encampment, and it is interesting to see the dexterity and quickness with which they construct these bothies.

Having now described the mode of obtaining the peat, and pointed out the two great difficulties involved in the supply of a large quantity of it for the purpose of fuel or for any other application, I will now request your attention to the nature of this material when it has been dried, and in the first instance as regards its application as fuel.

Even in the most favourable seasons, the air-dried peat retains a considerable amount of water—from 20 to 30 per cent.—as will be seen from the following results or analyses of different kinds taken from stacks a year old. (Table 1.)

This water cannot be separated from the peat except by kiln drying; but in order to illustrate the effect of this moisture on the value of peat as fuel, I will at first suppose that it has been so dried as not to contain any water. In that state the composition of peat may be taken as generally represented by the following proportions as compared with coal. (Table 2.)

Combustion, or that chemical process by which heat is generated from ordinary

* Paper read at a recent meeting of the Society of Arts

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fuel, consists in the combination of carbon and hydrogen with atmospheric oxygen.

TABLE 1.

LEWS PEAT.	Air-dried.	
	Per centage of water	Weight of a cubic foot.
		lbs.
1. Light brown fibrous turf	40	25
2. Blackish brown fibrous peat	26·71	53
3. Black peat very dense	25·39	54
4. " "	31·60	65
5. Brown peat	28·74	71
6. Browish black peat	27·76	78

TABLE 2.

	Peat.	Coal.				
		Welsh.	Newcastle.	Lancashire.	Scotch.	Derbyshire.
Carbon	60	83·78	82·12	77·90	78·53	79·68
Hydrogen	6	4·79	5·31	5·32	5·61	4·94
Oxygen	32	4·15	5·67	9·53	9·69	10·12
Ash	2	4·91	3·77	4·88	4·03	2·65
	100					

The amount of heat produced by the combustion of any kind of fuel depends, therefore, on the amount of carbon and hydrogen it contains. The amount of heat produced by any particular fuel, or its calorific power, is expressed by comparison with the amount of heat produced by the combustion of carbon, which is taken as unity. Hydrogen gas, when burnt, produces an amount of heat three times as great as that produced by the combustion of an equal weight of carbon to carbonic acid. The calorific power of hydrogen is therefore three times as great as that of carbon. The per centage composition of a fuel being known, it is easy to determine its relative calorific power, that of carbon being = 1000. When the combustible portion of the fuel consists of carbon only, as in coke or charcoal, the per centage of carbon expresses the calorific power or relative fuel value as compared with pure carbon. When the combustible portion of the fuel consists of carbon and hydrogen, the per centage amount of hydrogen multiplied by three and added to the number expressing the per centage of carbon, gives the calorific power of that fuel as compared with carbon; but when the fuel contains oxygen besides carbon and hydrogen, a portion of either or both of these constituents equivalent to the amount of oxygen contained in the fuel, must be regarded as already in combustion with oxygen, and therefore as ineffective for the production of heat. In such cases it is only the surplus carbon and hydrogen, over and above what are equivalent to the oxygen of the fuel, which can produce heat by combustion; therefore, the greater the amount of oxygen in any fuel, the smaller will be the calorific power. In this respect there is a great difference between coal and peat. The presence of a large amount of oxygen in fuel affects the calorific power in two ways, viz., by reducing the per centage amount of carbon and hydrogen, and by rendering a portion of those constituents ineffective for the production of heat. For this reason the calorific power of absolutely dry peat is only 660, while that of coal is from 996 to 903. Hence it will be evident that the maximum capability of peat as fuel is necessarily far below that of coal, even when the peat is absolutely dry. But, as I have already pointed out, that degree of dryness cannot be attained except by kiln-drying; and, the ordinary air-dried peat of good quality contains one-fourth its weight of water. Here then is a further reduction of the calorific power of this substance, by one-fourth, or to 495; about one-half that of coal.

In some cases where peat is needed for fuel it is essential to have it quite dry, and then it is worth while to kiln-dry it; but there is no saving effected by so doing. The 25 per cent. of water separated by kiln drying requires for its separation a determinate quantity of heat and a proportionate consumption of fuel, which is equally consumed without useful effect, whether the peat be used as fuel in the air dried state, or whether it be kiln dried before it is used.

These simple considerations will be sufficient to show what a palpable delusion it would be to suppose that peat could possibly be in any way equal to coal in fuel value.

The greater bulkiness of peat as compared with coal is another circumstance which operates against its application as fuel. The average of coal has a density corresponding to 80lbs. to the cubic foot, while air-dried peat has a density corresponding to only 64lbs. to the cubic foot. A cubic foot of coal, in the state in which it is used, contains about 60lbs., whereas peat in the same way weighs only 30lbs. to the cubic foot; so that with only half the calorific power it takes twice the space, and to produce a given effect with air-dried peat, it would require twice the weight and four times the bulk of the coal to produce that effect. Hence has arisen the idea of compressing peat. It is notorious that no success has attended any of the attempts to carry this idea into practice, and that this should be the case is very easily intelligible. Absolutely dry peat of the very best quality has a fuel value of 660 as compared with coal at 960; in order, therefore, that equal bulks of coal and peat should have the same fuel value, a cubic foot of peat must contain nearly one and a half times as much in weight as a cubic foot of coal, or nearly 116lbs. to the cubic foot, corresponding to a density of 1800. Whether such a compression of peat is or is not possible in practice I will not pretend to say, though I consider it very improbable; and even if it were effected so as to be of practical utility, there would still be the disadvantage attending the use of peat as fuel, that its calorific power would be only two-thirds that of coal, and that one and a half times as much must be used to produce the same effect.

As regards the use of peat for fuel, it now remains only to consider what are the circumstances under which it can be used for this purpose, and under which there is an advantage in using it rather than coal. I can best illustrate this by a case within my own experience. During the last four years I have had occasion to manufacture a large quantity of bricks in one of the Western Islands of Scotland, and for that purpose required fuel for raising steam to drive the brick machinery, and for burning the bricks. Coal could be delivered at the port of Stornoway at about 18*s.* per ton, and as the works were at some distance inland, there was a cartage amounting to 4*s.* per ton, making the cost of the coal 22*s.* per ton. But I found that the peat, of which there was abundance close to the works, was capable of raising steam well, and of being used for burning the bricks, and that, taking it to have only half the fuel value of coal, and even with very imperfect arrangements for bringing it in from the moor, I could for 8*s.* put down at the boiler or at the kiln a quantity of peat equivalent to one ton of coal, thus making a difference of 14*s.* between the use of a ton of coal and the use of peat equivalent to it. As the burning of the bricks required about half a ton of coals per thousand, this was equivalent to a saving of 7*s.* per thousand in the cost of the bricks. In this case, therefore, there was an unmistakeable advantage in using peat as fuel, and the advantage would have been still greater if there had been a more efficient means of bringing in the peat from the moor. In the case to which I now refer, this cost as much as the peat itself cost on the moor, or about 2*s.* per ton.

In the town of Stornoway, however, it is found to be more advantageous to use coal at the gas works, and as fuel for the steam boiler at the slip, and for general purposes, since there is no organised system for supplying the peat from the moors, which are three or four miles distant from the town, the consequence being that the gathering and cartage of the peat costs as much as 4*s.* or 5*s.* per ton over and above the cost of cutting and drying, or in all 6*s.* or 7*s.* per ton. At that cost it is evidently better to use coal, which is much more easily obtained, and which, being double the value of peat, is not much dearer.

From my own experience of the use of peat as fuel, I consider that wherever it can be had on the spot, and with a fuel value one-half that of coal can be put down at a cost of 4*s.* per ton at the place where it is to be used, it may be advantageously substituted, when coal, under the same circumstances, costs more than 10*s.* per ton; but if coal can be had for 10*s.* per ton, or less than that, there would be a disadvantage in using peat.

When the place where peat is to be used is far distant from the moor where it is cut, the cost of carriage, under the most favourable circumstances, amounts to twice as much as the carriage of coal, because the fuel value being only half that of coal, two tons of peat are required for one ton of coal. This necessarily limits the use of peat as fuel to places near the moors where it is cut.

Besides the compression of peat, various other modes of improving it for use as fuel have been tried; the general principle of all these modes of treatment is the kneading or pugging of the peat, so as to give it a more uniform and compact texture and greater density. Peat which has been prepared in this way will have, when dried, a density equal to that of coal; but I have never been able to perceive how these operations can be advantageously applied to peat, for the following reasons:—In the first place it must be remembered that to obtain a ton of dry peat it is necessary in the kneading or pugging which is intended to improve its texture to operate upon five tons of material. Supposing that to be rendered practicable by suitable mechanical contrivances, so as not to cost more than it is worth or more than is proportionate to the consequent improvement of the peat, it must be remembered that this kneading or pugging of the peat does not separate the water—it does not dry the peat. This—which is the greatest difficulty of all in regard to the use of peat—still remains to be done, and even admitting that some of the water may be separated by the pugging, there will be at least three tons of water to evaporate in order to obtain one ton of dry peat.

The idea of employing heat to evaporate that water, of drying the peat artificially, is quite out of the question, since the consumption of fuel for that purpose would be quite disproportionate to the value of the peat obtained. The only plan of drying that is practicable is air-drying, and to dry peat by exposure to the air it must be spread out over a large surface. Every ton of dry peat will require 75 square yards of drying ground; and if the quantity of peat required every year is 30,000 tons, the area of the cutting ground will be one square mile at least. Now if the peat is to be submitted to the operation of kneading or pugging, and has then to be dried by exposure to the air, it must, if the pugging machinery is fixed, be carried to the machine, and then carried back to the spreading ground. This carriage to and fro will amount to ten times as much as the carriage of the peat itself, and must add considerably to the cost. If, on the other hand, the pugging machine be locomotive, another obstacle to the adoption of this plan of treatment arises from the necessity of carrying out the cutting and spreading of the peat within a very limited time, as I have already pointed out.

Now, when we consider all these circumstances, and compare the cost of applying this treatment to peat with the results effected by its application, I think it must be obvious to any one acquainted with the peat districts, with the use of machinery, and with the value of fuel, that the attempt to apply such treatment to peat is like breaking a fly upon a wheel, that the means are totally disproportionate to the end, and that the use of peat as fuel is altogether dependent on local circumstances, the principal of those circumstances being the

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want of coal or the high price of it, and the presence of an abundance of peat of good quality. These are the circumstances which would determine the consumer of fuel in choosing peat or coal. It is entirely a question of cost. To the landowner there may be in some cases other inducements to promote the use of peat in place of coal, such, for instance, as the employment of a population which would otherwise be in idleness; the desire to clear away the peat and make land available for agricultural purposes: but these circumstances are all incidental, and of a nature foreign to the true merits of the question as to the value of peat as fuel.

I am quite convinced, however, that there are many places in the Highlands of Scotland, and perhaps also in Ireland, where the concurrent influence of a variety of circumstances favourable to the application of peat as fuel, is sufficiently great to admit of a vast amount of good being effected by carrying out the cutting of it on a large scale. Thus, for instance, steam communication between Glasgow and the various ports of the Western Islands of Scotland is still very expensive on account of the necessity of sending out the coal for the return passage of the steamers. The cost of the coal consumed in the steamers running between Glasgow and Stornoway is about £80 each passage, and there is much more than a mere probability that a judicious and liberal minded application of capital would be successful in establishing the use of peat as fuel in those steamers on their return passage to Glasgow. The applicability of the peat for this purpose is undubitable. I have employed peat as the only fuel for steam boilers during the last four years, and have found it to answer admirably. It has also been tried by Mr. James Napier, of Glasgow, on board his steamer the *Lancefield*, and he is of opinion that it might be used in the place of coal. The fact of its being only half the fuel value of coal would in this instance be counterbalanced by the advantage of its cost being less than that of coal. Besides this, the steamers running between Glasgow and the Western Islands are chiefly supported by the freights from Glasgow; their return cargoes are sufficiently small to admit of their using peat as fuel, although a greater weight and bulk would be needed of it than of coal. Moreover, the peat being a natural production and incumbrance of those islands, its use for this purpose would at once be a means of establishing a productive industry and also of affording what is so much needed there,—a great opportunity for employment—while at the same time the condition of the people would be bettered; and, by the removal of the peat, land would be cleared for cultivation, and the climate improved and rendered less unfavourable to vegetation. At present, however, the peat deposits of these islands and of the Highlands generally, though containing the elements of social amelioration, of industry, and of wealth, lie like a huge inanimate chaos, burying the land which might yield abundant harvests, preventing the labour of the inhabitants, and hindering the development and maturing of the crops on those few patches of ground which are yet cultivated.

The next application of peat, and that to which I purpose to refer more especially in this paper, is the manufacture of oils and paraffin from it by distillation.

It will doubtless be remembered that, in the year 1849, great interest was excited in Parliament and throughout the country by the announcement that a method of obtaining valuable products from the peat of the Irish bogs had been discovered, and that a company had been formed for the purpose of carrying out, on a large scale, the manufacture of those products from peat in Ireland.

The proposed undertaking was very warmly supported by the press, and was described in a popular journal as constituting an Irish El Dorado.

This mode of working peat was devised by Mr. Rees Reece. It consisted in distilling the peat in a kiln, much in the same way as Lord Dundonald, in 1781, distilled coal for tar, oil, &c., with this difference, that Mr. Reece employed a kiln constructed more in the form of an iron smelting furnace at the bottom, and that he employed, as in such iron furnaces, a blast of air for the purpose of maintaining the combustion of the peat at the lower end of the kiln, by which means heat was produced for distilling the peat at the upper part of the kiln. By thus distilling peat, a tar was obtained which, on subsequent distillation and treatment, yielded oil and paraffin.

In consequence of the very great public attention directed to this project, an investigation of the subject was instituted, at the suggestion of Lord Clarendon and the Chief Commissioner of Woods, by the chemical officers of the Museum of Irish Industry, under the direction of Sir R. Kane. The results of that inquiry were published in a Blue-book in the year 1851.

Among the products which were shown to be obtainable from peat, were paraffin and certain hydro-carbon oils, which it was proposed by Mr. Reece to use as solvents of india rubber and for lubricating machinery.

These oils and paraffin were obtained, in the first instance, as tar, by distillation of the peat, and the results given in Sir R. Kane's report go to show that there is no serious difference in the nature and amount of the produce,

TABLE 3.

KIND OF PEAT.	Pounds per cubic foot.	Peat Distilled in Retorts.			Peat Distilled in Kiln.			
		Per centage of Tar.	Per centage of Oil from Tar by weight.	Refin'd Oil from 1 ton tar, galls.	Per centage of Tar.	Per centage of Oil from tar by weight.	Refin'd Oil from 1 ton Tar, galls.	
1. Mixed light and dense turf (Phillipstown)	33·5	2·000	58·8	155	—	—	—	Sir Robert Kane and Mr. Sullivan.
2. Light surface turf (Allen)	21·0	3·577	46·1	121	2·510	55·3	144	
3. Dense peat (Allen)	29·7	2·767	43·8	115	2·395	43·1	113	
4. Light fibrous turf (Ticknevin)	30·3	2·916	70·2	184	—	—	—	
5. Light fibrous turf	30·3	2·344	64·2	168	—	—	—	
6. Light fibrous turf (Shannon)	17·5	4·417	38·2	100	—	—	—	
7. Dense Peat (Shannon)	53·3	1·462	70·1	184	2·270	50·0	132	
Average	—	2·787	55·9	147	2·391	48·5	128	
8. Dense mountain peat (Antrim)	—	—	—	—	4·440	—	—	Dr. Hodges.

whether the distillation of the peat be conducted in close retorts, or in kilns, as proposed by Mr. Reece.

The experiments that were made with different kinds of peat gave the quantitive results shown in Table 3.

There is some degree of discordance in these results, but, taking the average, it will be seen that the peat distilled in close retorts yielded nearly 3 per cent. of tar, and when distilled in kilns it gave nearly 2½ per cent. In the former case the tar gave, on the average, rather more than half its weight; and, in the latter case, rather less than half its weight of refined oils and paraffin.

It must be borne in mind that all the varieties of peat referred to in Sir R. Kane's report are true "bog peat," the only result quoted by Sir R. Kane for mountain peat being that obtained by Dr. Hodges, of Belfast, in 1850, from an experiment conducted by him with about 50 tons of peat at Newtown Commelin, in Antrim.

Taking the average of these results, the 100 tons of Irish bog peat would yield by distillation in close retorts 2 tons 15 cwt. of tar, which gave by subsequent treatment 409 gallons of refind oils and paraffin, and by kiln distillation the 100 tons would yield 2 tons 8 cwt. of tar, or 304 gallons of refined oils and paraffin.

If this tar, or the oils and paraffin it yields, be taken as the sole commercially valuable products from the distillation of the peat, and if the cost of the peat is taken as 2*s.* per ton, as set down by Mr. Reece, and quoted in Sir R. Kane's report, the tar would cost, for raw material alone, about £4 per ton, and the cost of raw material equivalent to one gallon of refined oils and paraffin would be 7*d.*

Adding to this cost of raw material the cost of making the tar and refining the oil and paraffin as amounting jointly to 1*s.* per gallon, the total cost of the refined product would be 1*s.* 7*d.* per gallon.

It is not very probable that at this rate of cost the manufacture of these products from peat would be very remunerative, especially at the present market price of these oils and paraffin; but in Sir R. Kane's report, which has especial reference to Mr. Reece's project for working peat, other products besides the oil and paraffin are taken into account as adding to the profits that might be expected from this undertaking.

These products are sulphate of ammonia, acetate of lime, and wood naphtha; and so much were they regarded as a source of profit to be anticipated from the working of peat, that in the prospectus of the Irish Peat Company they were set down as furnishing more than one-half of the expected profits of the works.

The values assigned to these products in Sir R. Kane's report are not indeed quite so great, as regards the amount, as those stated by Mr. Reece, but they are, nevertheless, considerable, being for the 100 tons of peat as follows:—

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Mr. Reece.

Sulphate of ammonia, 20 cwt. at 12s.	£12 0
Acetate of lime, 4 cwt. at 14s.	9 16
Wood naphtha, 52 gals. at 5s.	13 0
	£34 16

Sir R. Kane and Mr. Sullivan.

Sulphate of ammonia, 20 cwt. at 12s.	£12 0
Acetate of lime, 4 cwt. at 14s.	2 16
Wood naphtha, 52 gals. at 5s.	13 0
	£27 16

These results have a very attractive appearance, even in both cases; but a closer examination of the subject of peat working from a commercial point of view, led me to the conclusion that it is a fallacy to regard these products as constituting a source of profit to be obtained in working peat. On the contrary, I consider that no reliance should be placed on the value of these products as contributing in any way towards the possibility of peat being worked advantageously. They should be regarded strictly as waste or bye products, and the question whether peat can be worked remuneratively must be determined by regarding the oils and paraffin alone as the staple products. If these can be obtained in such proportion, and at such a cost as to afford a profit on the manufacture, it may then become a question to consider whether the bye products obtained in that manufacture are not worth working up for the sake of the ammoniacal salts and other materials they would yield. This question would be determined one way or another by a variety of circumstances of more or less special nature. Among others, the possibility of making some portion of the waste of the chemicals employed in the purification of the oils and paraffin, available for working up these bye products, would be of prominent importance, inasmuch as that would, to some extent, reduce the cost of purifying the oils, &c.

I shall have occasion afterwards to point out results corroborative of this view as to the really valuable products of peat.

Keeping this principle in view, meanwhile, I will now request your attention to the production of paraffin and oil from peat. In the early part of 1858, I was consulted as to the possibility of working the tar obtained from the peat of the Island of Lews, one of the Hebrides. The peat occurring in this island is, as I have before mentioned, a true mountain peat, and, like most of the peat in the Highlands of Scotland and north of Ireland, is a remarkably rich bituminous variety. It is of a dark brown or black colour, and heavier than water, weighing sometimes as much as 78 lbs. the cubic foot. It burns with a brilliant white flame, of great length, and considerable heating power, indicating the presence of a large amount of bituminous substance.

The tar obtained from this peat by distillation was quite solid at the ordinary temperature; it was of a dark brown colour, with a penetrating odour of creosote, and melted on the fingers like butter, in consequence of the paraffin it contained. Its density was 0·960.

The analysis of this tar showed that it yielded hydro-carbon oil and paraffin of good quality. Two samples, one made in a close retort, the other in a kiln, gave the following results by weight :—

	Retort.	Kiln.
Refined oil and paraffin	42·161	41·167
Creosote	30·459	47·068
Charcoal, gas, and waste	27·380	11·765
	100·000	100·000

These quantities correspond respectively with 112 and 107 gallons of refined oil and paraffin from the ton of tar.

About a ton of the tar was then operated upon for the purpose of getting the products in such quantity as would admit of their being tested as to their applicability for various purposes.

The oil obtained from the tar was purified by the ordinary methods of treatment applicable to such materials, and was then separated by distillation into two portions; one portion of the oil, amounting to about one-half of the gross refined product, was quite liquid even at low temperatures; it was of a pale yellow colour, with a slight and not unpleasant smell. It burnt well in the lamps commonly used for hyro-carbon oils, with a brilliant white flame. It did not carbonize the wick, while burning, or resinify by exposure to the air. Its boiling point being above 390° F., there was no danger of its giving off explosive vapour at any temperature it would be likely to be heated to when used in a lamp, and, as compared with some other oils of good quality, it gave, measure for measure, a greater quantity of light.

The other half of the oil was partly solid at the ordinary temperature; it consisted of an oil of greater density than the one I have just mentioned, and of higher boiling point, mixed with a great quantity of paraffin partly in solution and partly crystallised. This paraffin was easily removed by a filtering bag and the dissolved portion was separated, by cooling the oil and then filtering it again. The paraffin thus obtained amounted to about one-tenth part of the gross refined product. The oil from which the paraffin had been separated was, like the other oil, of a pale yellow colour, and had scarcely any smell. It burnt with an intense white luminous flame, and when mixed with fat oils formed an excellent lubricator.

The proportion of refined oil and paraffin which I obtained from the ton of tar was about 112 gallons in all; in round numbers it might be said that on a working scale the tar on which I operated would give 100 gallons refined oils and paraffin per ton. This was very much less than the average amount of the products obtained by Mr. Sullivan from the Irish peat, as stated in Sir Robert Kane's report; but, on the other hand, the amount of tar obtained from the Irish peat was very small, and I expected, from the difference between the peat operated upon by Mr. Sullivan and that of Lews, that this latter, being of a much more bituminous character, would yield by distillation a larger amount of tar.

With regard to the possibility of carrying on the manufacture of these products on a large scale, everything depended upon the cost at which the tar could be produced. Juding from the results that had already been obtained, it appeared to me that £5 per ton was the maximum price that could be allowed for the tar, supposing it to yield 100 gallons of refined oils and paraffin, and that with this cost for the tar, it would be possible to work it profitably if the purification of the oils did not cost more than six-pence per gallon.

These limits having been fixed as to the cost of tar and refining the oils, it became requisite to ascertain the cost of the peat, the amount of tar it yielded, and the cost of production. At that time the cost of the peat on the moor was 2s. 6d. per ton for cutting, drying, and stacking, by contract, but there were satisfactory reasons for expecting that it could be obtained at a less expense. These expectations were subsequently realised, peat having been obtained by contract in succeeding years at 2s., 1s. 9d., and 1s. 6d., per ton; and some which I had cut under my own direction did not cost more than 1s. per ton stacked on the moor. I now think that from 1s. to 1s. 6d. per ton might be fairly taken as the prime cost of air-dried peat containing 20 to 30 per cent. of water.

(*To be continued*).

REVIEWS AND NOTICES OF NEW BOOKS.

The Mineral Resources of Central Italy, Including a Descripton of the Mines and Marble Quarries. By W. P. Jervis, F.G.S., Assistant-General to the Italian Special Commissioners for the Exhibition. London: Stanford, Charing-cross. 1862. Price 3s. 6d.

This work is one of a valuable series of books on the mineral resources of the various countries represented at the International Exhibition, 1862, in course of publication, and Mr. Jervis has performed, in a masterly manner, the task he undertook of bringing before the English public, in a succinct form the highly interesting and valuable statistics and scientific history of the mineral resources of that interesting geological country, Central Italy.

As the great source of supply to the world of marbles for statuary and architectural embellishment are the quarries of Carrara and those adjacent, their productions are described minutely, but Mr. Jervis has not confined himself to the marbles, for although that subject has had ample justice done to it, in one chapter consisting of about twenty-two pages of letter press and the acompanying wood-cut illustrations, there are fifteen chapters in all, the remainder being devoted to alabaster, serpentine, boracic acid, rock salt, tin, copper, lead, silver, mercury, antimony, manganese, the various metalliferous minerals, the etruscan art metal-work, and the mineral fuel and ores of Italy. Each chapter has peculiar interest, either scientific or commercial, and many both in an eminent degree. Mr. Jervis's book deserves the most extensive sale.

The Builders' and Contractors' Price Book for 1863. Revised by George R. Burnell, C.E. and Architect. London: Lockwood and Co., 1863.

We have in past years noticed this annual, and called attention to the alterations and improvements introduced from time to time. Mr. Burnell has, in the edition for this year, revised the prices for nearly all the trades included in the book, and has made various improvements which will be appreciated by all those for whom the work is intended.

This Price Book does more than maintain the good reputation it has so justly deserved, by keeping pace with the advances and changes made in the several trades, and thoroughly meeting the requirements of those to whom it is dedicated.

Solutions of Questions in Arithmetic by First Principles. By Walter McLeod, F.R.G.S., M.C.P. London: Longmans. 1863.

Mr. McLeod is the head master, &c., at the Royal Military Asylum, Chelsea, and is the author of some very useful and cheap arithmetical works, such as *The Six Standards of Arithmetic, A Manual of Arithmetic, Mental Arithmetic According to the Method of Pestalozzi*, &c. The present work is dedicated very appropriately to the Rev. Henry Moseley, M.A., F.R.S., the well-known and highly esteemed Canon of Bristol.

We extract the following from the author's "introduction" as the best explanation of the author's views, and of the nature of the work before us :—

"The present work, the result of many years' experience, contains full solutions of questions in simple and compound proportion, per centages, commission, interest, discount, stocks, profit and loss, and partnership, by first principles, in a form adapted for elementary instruction.

"In nearly all our text books in arithmetic, examples, such as those solved in this manual, are worked by statement, according to certain rules, which the pupil has first to learn by heart before he attempts the solution of a question. And when a pupil thus taught sits down to solve a problem, he generally finds himself involved in an impenetrable maze. He asks for guidance in his work, and is directed to the rule. He does as required; and by puzzling and repeated trials, he at length obtains the answer given in his book; but so far as the reasons of the process, and the principles of the rule are concerned, he remains in total ignorance.

"If there is to be any real, thorough teaching, the pupil must be made to understand the reason for every operation he performs. He is not to be a mere mechanical cipherer, but an intelligent agent—one who understands what he is doing, and can reason out every step in the solution of a question.

"The method adopted in this volume dispenses with rules altogether; and the most difficult questions in arithmetic, as will be seen on examination, are solved without statement, and by means of multiplication and division only. The method, moreover, is characterised by great simplicity; and every step in the solution of a problem is an intellectual exercise.

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"But although the method has been so strongly recommended, and some authors of Arithmetical School-Books have adopted it in the solutions of easy questions, still no work has attempted to show that it is applicable to the most difficult problems in the higher branches of arithmetic. To bring the method, therefore, into more general use, and to supply teachers with a carefully selected series of questions, all solved by first principles, has been the aim of the author in the publication of his book of selections."

The Engineer's, Architects and Contractor's Pocket Book for 1863. London: Lockwood. 1863.

The present publishers, Messrs. Lockwood and Co., deserve great credit for the improvements which have been introduced into the *Engineer's Pocket Book* since it came into their hands. The present edition contains several additions and improvements, and a few well-selected, scientific and practical papers, and some brief memoirs of the scientific and other men of note recently deceased.

The tables for the reciprocal conversion of British measures of length, superficies, capacity, &c., into metric measures, and similar tables for the translation of measures of weight, which have been much wanted, will be found a valuable addition amongst many others introduced in the *Engineer's Pocket Book* for this year.

Electrical Accumulation and Conduction. Part I. By F. C. Webb. London: E. and F. N. Spon.

The author has collected and published, in a small volume of 156 pages, a series of highly scientific and valuable papers, originally printed in *The Electrician*, a journal devoted to electric science, telegraphy, &c. It will also be remembered that Mr. Webb recently read a very interesting practical paper upon the same subject before the Institution of Civil Engineers, which was esteemed as one of the best papers of the session. He is so thoroughly master of the subject, that a treatise on the principles of electrical accumulation and conduction could not have been written by any one more capable; and as the extension of the submarine or oceanic lines of electric telegraph mainly depends upon a more perfect knowledge of those laws which govern the economic transmission of currents through metallic wires (although doubtless these are questions of improved structural combinations and arrangement of parts of cables for deep sea lines), the present work serves to call the attention of those who are engaged in electric telegraphy to most grave and important questions.

An Inquiry into the Deposition of Lead Ore in the Mineral Veins of Swaledale, Yorkshire. By Lonsdale Bradley, F.G.S. London: Stanford, Charing-cross.

The author has pursued his investigations into the mineral characteristics of the mountain limestone formation of Swaledale in a most careful, elaborate, and highly scientific manner, and in the volume before us has given a series of ten coloured sections of the various veins and stratifications comprised within an area of about 200 square miles; the number of distinct metallic veins cut and more or less explored being 192, of which number about 170 are said to be fairly productive.

The work is highly deserving of the attention of geologists and mineralogists, as most of the facts that result from Mr. Bradley's inquiry, and recorded by him, may with great advantage be applied elsewhere.

Mathematics for Practical Men. By Olinthus Gregory. The Fourth Edition, revised and corrected by J. R. Young (formerly Professor of Mathematics at Belfast College). London: Lockwood and Co., 1862.

Olinthus Gregory's *Mathematics for Practical Men* having justly earned almost a world-wide reputation in years gone by, it is unnecessary to do more than announce the publication of the fourth edition, after a careful mathematical revision by Professor J. R. Young.

The portion devoted to Pure Mathematics may be said to be unexceptionably excellent: but we cannot forbear suggesting that there is to be found in Part 2, under "Mixed Mathematics," much that is obsolete, and should be omitted—as being useless to practical men, and likely to mislead the student. The illustrations of quaint kinds of steam engines and machines—still retained at the end of the book—gives it an air of antiquity which ought not to attach, for as a standard work on mathematics it has not been excelled.

NOTICES TO CORRESPONDENTS.

R. C.—Your communication is to hand. We shall be glad to receive and give due consideration to the observations upon the subject to which you refer. We will write you in reply to your postscript.

"Aspel."—Yes. We will insert the particulars, if possible, in our next.

Constant Reader.—The date of Weston's Patent is April 25th, 1859.

W. R.—Your notes are to hand. We have used them, as you will perceive.

J. W.—We should take thefollowing formulæ:—$F = R \times P$. $R = \frac{F}{P}$ where R = the co-efficient of friction. P the pressure and F the friction. The co-efficient R varies from ·054 to ·15. The variation depending upon the lubrication of the metal. The formulæ of Whitworth are well adapted for your purpose.

Errata.—*Locomotive Engineering.*—In the Artizan of Dec., p. 270, second column, where criticising Mr. D. K. Clark's formula:— $\left(R\,t = 6 + \frac{V^2}{240}\right)$ line eleven of the paragraph immediately following the above formula, for the words to the *square* of that speed, *read* to the *cube* of that speed; and after the word *speed* in the same line, insert the following:—*whereas it is one of the fundamental laws of mechanics that such work is proportional to the square of the speed.*

Obituary.

THE EARL OF GIFFORD.

We have to announce the death of the Earl of Gifford, which took place at Dufferin Lodge, Highgate, on the morning of the 22nd December, 1862, after a protracted illness. The deceased was the eldest son of the Marquis of Tweeddale, and was born 1822, at Yester House, Haddingtonshire. He was educated at Trinity Hall, Cambridge, where he graduated M.A. in 1845. The deceased earl was well known for his scientific attainments, and was one of the first who was elected on the Committee on Steam Performance, appointed by the British Association for the Advancement of Science, of which he remained a very zealous member up to the time of his decease.

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.

Spencer v. Jack and Rollo.—This was an action tried in the Court of Common Pleas, lasting three days, and concluded on the 17th ult., brought on behalf of a consulting engineer, of Newcastle-upon-Tyne, against the defendants, engine makers of Liverpool, for the infringement of a patent taken out by the plaintiff in 1860, for certain improvements in marine steam engines. Mr. Lush, Q.C., Mr. Streeton, and Mr. T. Webster appeared for the Plaintiff; Mr. Bovill, Q.C., Mr. Hindmarch, Q.C., and Mr. T. Jones for the defendants. The claim of the plaintiff under his patent was twofold:—first, in the arrangement of inverted direct acting screw engines, a disposition of surface condensers, by which the external casing thereof forms part of the main framing, and is placed between and under the cylinders of such engines, and the tubes whereof, being horizontal and inclined, are placed across the line of the keel or propeller shaft; secondly, in the arrangement of paddle wheel engines, a disposition of surface condensers, by which the external casing thereof is placed between the cylinders, and may or may not form part of the main framing of such engine. The tubes whereof of such condensers, being horizontal or slightly inclined, are placed across the line of paddle shaft and in line with the keel. The defendants denied the novelty of the invention, but, after a short deliberation, the jury found for the plaintiff as regarded both cases.

Kottula v. Palmer and Others.—This was an action tried in the Court of Queen's Bench, on the 12th ult., by the assignees of Messrs. Blake and Maxwell's patents for improvement in the manufacture of soap, dated August 30th, 1856, against Messrs. Palmer and Co., the well-known patent candle and lamp makers. After the time of the Court had been occupied some two days, some witnesses for the defendant proved that soap, precisely the same as that the making of which was alleged to be an infringement of the plaintiff's patent rights had been made from a recipe in Kurten's book upon the subject before 1856, and soon after the work was known in England in 1853. The plaintiff elected to be nonsuited. The Lord Chief Justice said the case furnished another proof of the unsatisfactory state of the law as regard patents.

Clark v. Metropolitan Railway Company.—This action was brought to recover damages for injury done to two houses at Cow-cross by the works of the underground railway. It appeared that it was necessary to divert a certain sewer in order to construct the railway at Cow-cross, and in consequence of the excavation for that purpose the houses of the plaintiff were so damaged as to require rebuilding. The alleged negligence on the part of the defendants was that they had brought the new sewer too near the houses when they could have taken it in another direction where it would not have affected the safety of the buildings, and that the houses were not completely and effectively shored up before the excavation. The works were executed for the Company by Mr. Jay, the contractor; and it appeared with the sanction and under the supervision of the Board of Works. The expense of rebuilding the houses was estimated at £1200, and the defendendant claimed £700 as compensation from the company, the difference being the increased value of the property after the rebuilding. On the part of the defendants it was submitted that the contractor who did the work was liable for any injury done to the property, and not the company. Mr. Baron Martin held that if the company employed a contractor to do certain works, that did not relieve them from responsibility for the general mode in which they had been carried on. A verdict was ultimately returned for the plaintiff—Damages, £700.

Mare v. Churchward and Another.—In this case the plaintiff (the well-known ship-builder) sought to establish his right to a moiety of the net profits arising from the government contract for the conveyance of the mails between Dover and Calais, and Dover and Ostend, and also to a moiety of the profits arising from a contract with the French government for the conveyance of the French mails between Calais and Dover. The bankruptcy of the plaintiff was, as our readers are aware, superseded, upon his paying his creditors 4s. in the pound upon their debts. This he did with the assistance of his father-in-law, Mr. Peter Rolt, who had proved a debt against the plaintiff's estate to the amount of £133,000. Instead, however, of taking the composition upon his debt, it was arranged that he should, under a deed executed under the sanction of the commissioner in bankruptcy, have an assignment of the surplus assets of the estate after payment of the composition, including the benefit of the contract for the Dover mail service. According to the case made by the bill, a sub-arrangement was made between Mr. Rolt and the plaintiff that the former would re-assign to the plaintiff the interests in these contracts upon the payment of the sum of £5000. On the other hand it was contended, on the part of Mr. Rolt, that another sum of £7031 was to be paid to him, in addition to the before mentioned sum of £5000, before the re-assignment could be asked for; and that the plaintiff, not having tendered both the sums referred to, Mr. Rolt, in 1858, assigned the interest in the Dover mail service, vested in him under the deed of arrangement, to Mr. Churchward, for a valuable consideration; and the present suit was instituted for the purpose of impeaching the latter assignment. His Honour, without calling upon the defendant's counsel, said that if Mr. Rolt had even entered into the contract to re-assign to the plaintiff the benefits of the mail service contracts for the sum of £5000 only, the plaintiff had been guilty of great *laches* in not sooner seeking the assistance of the Court; and, upon that ground alone, the bill must stand dismissed with costs.

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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 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 (for which we are chiefly indebted to the *Chemical News*), 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.

LARGE CASTING.—Ryhope, one of the largest collieries in the North is at present worked by one shaft. The owners, however, have determined to proceed at once with the formation of a second one, and for this purpose they have ordered Messrs. Murray, of Newcastle-on-Tyne, to erect an engine of 200-horse power, to assist in the sinking of the shaft, and to draw up the coals when it is completed. Recently the single cylinder of this engine was cast in Chester-le-Street Foundry. The cylinder, which is 68 inches in diameter, 8ft. 6in. in length, and 8 tons in weight, was cast with complete success, and the sight was a very interesting one. Some idea of the extent of the casting may be formed when it called into requisition two large smelting furnaces, ten tons of molten metal, and upwards of fifty men, besides three large cranes. When this engine is completed Ryhope Colliery will be worked by three 200-horse power engines, capable of drawing the enormous quantity of 3000 tons of coal per diem. Messrs. Murray are also engaged in building, for the same mine, two double-cylinder horizontal engines, of 200-horse power each, for the underground workings.

A MERCHANT STEEL SHIP.—Messrs. Jones, Quiggen, and Co., of Liverpool have lately contracted to build of steel, for a merchant house, a vessel of 1200 tons. This will be the first merchant vessel built of that material. The plates will be manufactured at the Mersey Steel and Iron Works.

CENTRIFUGAL PUMPS.—The successive improvements which may be traced through the class of water wheels as chief motors in transmitting power, in which the modern turbines are conspicuous, have also suggested a reverse action, by which the wheels and turbines are changed into pumps, of which many different patterns are now, and have long been, in use, operating as suction and force lift pumps. The laws of maximum useful effect, which have been very fully and clearly demonstrated for water wheels, as types, apply to their reversed patterns, as to the form and arrangement of the blades, experiment having demonstrated a large increase of the discharge with a change from ordinary radial to properly curved arms, without increase of power. The following abstract of an experiment by Colonel Morin, made at the Exhibition, illustrates this point;—

Form	Revs. per minute.	Gallons raised per minute.	Height raised.	Useful effects.
Curved vanes (Appold's).....	792	1164	18 ft. 8in.	·649
" "	788	1236	19 ft. 4in.	·680
Inclined vanes (45 deg.).....	694	560	18 ft.	·394
" "	698	736	18 ft.	·434
Radial vanes	624	369	18 ft.	·232
"	720	474	18 ft.	·243

With the best form of pump which can be devised, useful effect is controlled by velocity and lift, and the value of this motor is confined to low lifts under excessive speeds. Experiments made on Appold's centrifugal pump show a progressive per centage of work done under a lift of 5·5ft., with a 12in. pump, of 21·2 per cent. for 375 revolutions; 59·1 for 400; 71·9 for 495; an increase to 607 revolutions giving 69·2 per cent. To raise water 67·86ft. required a speed of 1·322 revolutions; and within their special range of application, 70 per cent useful effect is all that can be claimed for the best motors of this class. The laws of form, however, have been much overlooked in those in ordinary use, radial blades being common in practice. For baling large quantities of water from foundations in excavation, and for other uses where the supply carries much sand and gravel, and the facility with which dirt, gravel, grain, &c., are passed through these pumps is a strong point in their favour, while they have no claim to merit on the ground of economy in power.

EXPLOSIVE COMPOUNDS.—M. Reuy, of Vienna, has patented the manufacture of an explosive compound by treating cotton or other lignin substance, whose chemical formula is C_{12} H_{10} O_{10}, with nitric acid in a peculiar manner, whereby he obtains an explosive compound C_{12} H_7 N_3 O_{22}, which may also be expressed $C_{12} + H_7 3NO_4 + O_{10}$. The cotton yarn is loosely twisted; washed in pure running water, or under a fall for 48 hours and squeezed; dried in chambers at 122° Fahr. for 6 to 12 hours; the perfectly dried yarn is treated with monohydrated nitric acid of 1.52 sp. grav., and monohydrated sulphuric acid of 1.14 sp. grav. The acids are mixed and allowed to rest for 24 hours; the yarn is immersed in this mixed acid for 48 hours in pots under covers, and frequently stirred; the excess in the yarn is then thrown off by submitting the yarn to the action of a centrifugal machine; the yarn is then washed in fresh running water for 48 hours or upwards, and again dried; soaked in silicate of potash and squeezed; it is then washed for six days in running water, and dried, an excellent gun-cotton being the result. The cotton is most explosive, but entirely free from self-explosion, its explosion is not attended with smoke; its power can be regulated at pleasure; and, weight for weight, it has a force equal to six times that of the strongest gunpowder.

EFFECT OF GALVANIC ACTION ON IRON SHIPS.—It appears that it has now been proved beyond question that the coating of iron ships with preparations of copper, results in a galvanic action which entirely destroys the iron plates, by converting them into a substance much resembling plumbago. The effect of this action has become very manifest in the case of *La Gloire*, the whole of the plates of which will have to be removed below the water line, and in one of our own ships the action has been no less remarkable. Fortunately, however, the Admiralty have now adopted a substitute, which entirely obviates the difficulty. The *Triton* has been thoroughly repaired at Devonport Dockyard, and is now coated with Messrs. Peacock and Buchan's preparation. It will be recollected that some years since Capt. Peacock issued a pamphlet on the subject, and that more than two years have elapsed since he pointed out to the Ministers of the Marine in Paris and Madrid the danger of using copper.

TENDERS FOR BRITISH IRON FOR GOVERNMENT.—The tenders for the supply of British iron to Her Majesty's dockyards were recently opened, in the presence of the Lords of the Admiralty. There was considerable competition in the iron trade for this extensive contract, judging from the large attendance of representatives of the leading firms and manufacturers of Staffordshire and London. The successful competitors were the old established firms of Moser and Sons, of Southwark and Upper Thames-street, who have held the contract for six years.

MANUFACTURE OF IRON AND STEEL.—An improved apparatus for manufacturing malleable iron and steel has been patented by Mr. E. B. Wilson, of Parliament-street. The apparatus is a new form of Bessemer's converting vessel, in which the air is conveyed through a throat from the bottom instead of through tuyeres in the usual manner. The throat is turned up so as to form an inverted syphon, and when the iron is sufficient aerated, the vessel may be turned on the trunnions upon which it is hung, and the refined iron or steel poured into the ingot moulds, or otherwise.

SAFETY VALVES OF STEAM BOILERS.—At a meeting of the Academy of Sciences of Vienna, M. de Burg gave an account of his experiments on the mode of action of the safety valves of steam boilers. These results are in contradiction with the theoretical propositions upon which the regulations for the dimensions of these boilers have been based, inasmuch as in reality these valves do not rise to a height equal to one-fourth of their diameter, that is, one or more inches, but only so as to leave a passage for the steam whose diameter does not exceed the fraction of a line. These apparatus, therefore, cannot fulfil their object, which is to give simultaneous issue to all the steam which a boiler can produce when it has reached a determinate degree of tension, and thus to prevent all danger of explosion. To fulfil this purpose they ought to be at least six times, and in some cases twenty times larger than the rules prescribe.

MANUFACTURE OF STEEL.—An important discovery has been made by Mr. Anderson, the Assistant-Superintendent of Woolwich Arsenal, of a simple process, by which steel is rendered as tough as wrought iron, without losing its hardness. This change is effected in a few minutes, by heating the metal, and plunging it into oil, after which the steel can be bent, but not easily broken.

THE ELECTRIC LAMP FOR LIGHTHOUSES.—In one of his reports on the Dungeness light, written during the present year, Professor Faraday mentions an interesting experiment. Arrangements were made on shore (Mr. Holmes being in charge of the light), by which observations could be taken at sea about five miles off, on the relative light of the electric lamp and the metallic reflectors with their Argand oil lamps. At the given distance the eye could not separate the two lights, but by the telescope they were distinguishable. The combined effect was a glorious light up to the five miles. Then, if the electric light was extinguished, there was a great falling of in the effect; though after a few moments' rest to the eye it was seen that the oil lamps and reflectors were in their proper state. On the other hand, when the electric light was restored, the illumination became again perfect. Then, while both were in action, the reflectors were shaded, and the electric light left alone; but the naked eye could see no sensible diminution; nor when the reflectors were returned into effectual use could it see any sensible addition to the whole light power; though the telescope showed that the alteration in the lantern had taken place at the right time. Such was the power of the electric light that the addition or subtraction of the light of a fully effective set of reflectors, with their lamps, would not have been sensible to a mariner, however observant he might have been. Professor Faraday enumerates some points which are against, and others in favour of the light. In the first place, the simplicity of the present system is very great compared with that of the electric light; only two keepers are required to a lighthouse; they need possess no special knowledge; ordinary attention is all that is necessary; and thus failures of the light are almost impossible. In the new system a second set of men will be required to attend the engines, and there must be amongst them one or more who understand the principle and construction of the lamp in the lantern, of the magneto-electric machines, the steam engines and the condensers, and be able to make effectively the repairs necessary to the apparatus. In the next place, the expense of the new system must be large compared with that of the present system. Other objections have been made, of which Professor Faraday cannot see the force, namely, that the light is too bright—that it gives a false impression of the distance of the lighthouse—and that it blinds the eyes of the mariners to the perception of the lights on board vessels between it and them. These objections, he says, if they have any force, must be judged by mariners themselves. The points in favour of the magneto-electric light are strong and clear in relation to the increase of light. In cases where the light is from lamp-flames fed by oil, no increase of light at or near the focus or foci of the apparatus is possible beyond a certain degree, because of the size of the flames; but in the electric lamp any amount of light may be accumulated at the focus and sent abroad, at, of course, an increased expense. In consequence of the evolution of the light in so limited a focal space, it may be directed seaward, diverging either more or less, or in a vertical or horizontal direction, at pleasure, with the utmost facility. The enormous shadow under the light produced by the oil-flame burner, which absorbs and renders useless the descending rays to a very large extent, does not occur in the magneto-electric lamp; all the light proceeding in that direction is turned to account; and the optical part of the arrangement, whether dioptric or reflecting, might be very small in comparison with those in ordinary use. With reference to the final experiment now taking place at Dungeness, though Professor Faraday thinks that many changes might be made in the size, arrangement, and adjustment of the optic apparatus, he reserves these points for ranges and future consideration, aided by the instruction that will arise from the results of experience.

IRON-MAKING—"BLOOMING."—The patent blooming, recently erected at the Dowlais Ironworks, South Wales, was started on the 6th ult., and came off very successful. It consists of a series of vertical and horizontal rolls, which are placed in such a manner that the bloom on being entered in the first pair, passes through the entire train without the assistance of roughers, hookers, &c., at the rate of 300 blooms per hour. It is the invention of Mr. Charles White, of the Taff Vale Ironworks, Treforest, and is said to be one of the greatest improvements known in the ironworks for many years.

PNEUMATIC DESPATCH.—On the 24th ult. the tube for the conveyance of letters, parcels, newspapers, and packages, on the pneumatic despatch principle, and which has been carried underground between the railway clearing-house of the London and North-Western Railway in Seymour-street, Euston-square, and the North-Western District Post Office in Eversholt-street, Hampstead-road, was completed. The engine-house is a neat brick building on the London and North-Western Railway Company's Station. The engineers report to the directors that the tube will be ready for public traffic early in the present month.

THE FEN DRAINAGE.—The wind and tide of the 21st ult. made a complete wreck of Mr. Page's dam at the entrance of the Norfolk Marshland Smeeth and Fen drain. The dam had been in course of construction since the previous October, and about £9000 had been expended on it. At a meeting of the committee of the district at Lynn on the following day, it was resolved to rescind the appointment of Mr. Page as engineer, and the dam and banks have been entrusted to Mr. W. D. Harding, C.E., of Lynn, with whom a committee was appointed to co-operate.

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NAVAL ENGINEERING.

Our Steam Strength.—At the distribution of Queen's Prizes and Society of Arts' Certificates, held at the Manchester Mechanics' Institution, Dr. Fairbairn, speaking on our steam strength, said:—The extent of this force in this country alone in 1859 was as nearly as follows:—In mining and metal manufactures, the steam engines employed represented the nominal power of 450,000 horses, indicating in reality 1,350,000 horses' power. In manufactures the steam engines represented a nominal power of 1,350,000, or, in reality, 4,050,000 horses' power. In steam navigation, the engines employed represented a nominal power of 850,000, or, in reality, 2,550,000 horses' power. In locomotion, the engines employed represented the nominal power of 1,000,000, or, in reality, 3,000,000, horses' power, the total nominal power being 3,650,000, or, in reality, 10,950,000 horses or about 11,000,000 horses' power, each raising thirty-three thousand pounds one foot high in one minute, or equivalent to the enormous force of raising 162,053,575 tons one foot high in one minute, or 1,620,535 tons to a height of 100 feet in the same time. This was estimated as the work done per minute three years ago, now it had increased to upwards of 12,000,000 horses' power, which might be taken as the motive power in the British isles alone. It would be interesting to know the quantity of coal consumed for the purpose of generating a force equivalent to raising the above enormous load of 9,723,214,500 tons one foot high in an hour. This would require the strength of 11,000,000 horses to accomplish in one hour, and this multiplied by five, the average consumption of coal per hour per horse power, gives 24,533 tons, or about 25,000 tons, as the rate of consumption per hour for the steam power of Great Britian and Ireland.

The "Royal Sovereign."—On the 12th ult., the bending to the required shape of the first of the armour plates for this frigate took place. The plate was brought to the necessary form in two heats. The bottom of each furnace which has been built for heating the plates, is moveable, and consists of a strong iron frame, mounted on four wheels. The top of the framework, which is covered with layers of firebrick, thus forming the bottom of the annealing furnace. On these layers of firebrick, the plate for heating was laid by the aid of ponderous cliphooks, from a beam suspended from a travelling tubular crane. The plate in position, the carriage or bottom of the furnace was drawn into the necessary heating position. The plate having been brought to a sufficient heat was withdrawn from the furnace on its carriage, and was then seized by the cliphook, and conveyed by the travelling crane over two rows of massive iron bars, each row being 4ft. apart, fixed upright on an iron bed, the rows of bars exceeding in length the length of the plate. The upper ends of these upright bars are secured by two transverse bars of great strength, and are fastened by nuts and bolts. Between these upright bars are thrust other massive bars, which have been forged to the exact curve wanted to be given to the inner surface of the armour plate. These moulded bars rest on the iron below, their ends being held securely by the lower ends of the upright bars on each side. The heated armour plate was next lowered by the crane and cliphooks upon the moulded bars, and between the rows of upright bars. Other massive bars, moulded to the same form as those underneath, were then laid on the top of the plate, with their ends projecting through the upright bars. Heavy iron wedges were driven over each end of the upper moulded bars by slung iron bars of some hundredweight each, and the armour plate gradually yielded to the strain thus brought to bear upon it.

The "Royal Oak."—The contract price paid by the Admiralty for the plates affixed to this frigate is £37 per ton. The plates have an uniform weight of four tons, making each cost £148. Taking the number required to encase the *Royal Oak* at 280, the total cost of the armour plates alone may be set down at upwards of £40,000; in addition to which, the most powerful machinery is required to bend, shape, polish, and otherwise prepare the slabs of iron before they are fit to be bolted to the vessel's side, thus raising the cost of each to nearly double its original price.

The "Meanee," 60 guns, 2591 tons, 400 horse power, finished her trials at the measured mile, off Maplin Sands, on the 13 ult., previous to her departure for the Mediterranean. The following are the results of the trial:—the ship's speed at full boiler power 9·756 knots; number of revolutions, 60½; vacuum, 25½; pressure of steam, 20; draught of water forward, 22ft. 10in.; aft, 24ft. 8in.; pitch of screw, 19ft.; diamater, 17ft. At half boiler power the average speed was 6·957 knots; vacuum, 26; pressure of steam, 20; revolutions, 60. The trial was considered to be very satisfactory.

The "Columbine," 4, screw gun vessel, 669 tons, 150-horse power, underwent her trial trip on the 16th ult, at the measured mile off Maplin Sands. The *Columbine* made six runs at the measured mile, giving a result of 9·614 knots per hour, with 102 revolutions per minute; vacuum, 23; pressure of steam, 20. During the trial there was scarcely any perceptible vibration from the working of the machinery. After the trial of speed, the steering qualities of the vessel, with the old rudder, was tried, and the results noted for comparison with a similar trial, to take place with Lumley's patent steering apparatus. The first trial was at full speed, helm starboard at an angle of 23 degrees, when the circle was made in 4 min., 26 sec., the diameter of the circle being 536ft. The second trial was from dead stop, helm starboard, at an angle of 35 degrees; the circle was made in 4 min., 30 sec.: diameter, 693ft. In the third trial at full speed, helm port, at an angle of 18 degrees, the circle was made in 5 min., 5 sec.; diameter 1718ft. Fourth, from dead stop, helm port, at an angle of 27 degress, the circle was made in 4 min., 28 sec., diameter, 693ft. In the fifth at full speed, helm starboard, at an angle of 11 degrees, the circle was made in 7 min., 48 sec. In the sixth at full speed, helm port, at an angle of 11 degrees, the circle was made in 11 min., 20 sec.

The "Lily," 200-horse power, commissioned for the North American and West India Station has made her last official trial trip. The *Lily* attained an average speed, at full boiler power of 10·087 knots per hour, pressure of steam being 19½; vacuum, 25; revolutions of engines, 80; at half boiler power the average speed was 8·466 knots; pressure of steam, 16½; vacuum, 25; revolutions, 69. The circle was made at full speed in five minutes, being equal to a rate of 10½ knots per hour. The machinery and vessel worked in an excellent manner, and the result of the trial was highly satisfactory.

Government Steam Troop Ship "Orontes."—This vessel has been launched from Messrs. Laird's yard, at Birkenhead. She is the first government troop ship, and the largest ever built on the Mersey—being 300ft. long, 44ft. 7in. broad, 32ft. deep, with a register measurement of 2811 tons. She bears a great resemblance to the *Himalaya*, the successful working of which vessel has convinced the government that troop ships specially built for the purpose are more advantageous. The *Orontes* will accommodate 1100 to 1200 soldiers, in addition to her complement of officers and crew. She is constructed of iron, is of immense strength, and will be fitted with engines of 500-horse power. The total tonnage of vessels now building in Messrs. Laird's yard is between 1700 and 1800 (including the armour-plated frigate *Agincourt*), giving employment to nearly 3000 men in the various departments. It is worthy of remark that the *Agincourt* 700 tons larger than the *Warrior*, is being built in a dry dock to avoid the risks of ordinary launching, and will be ready in twelve months.

New American Screw Ram.—A New York paper states that the *Dunderberg* is being built 378ft. long, 68 broad, 32 deep, with engines of 6000-horse power. The hull is built of wood, placed together so as to form a solid mass. The decks, sides, and floor are also solid, and of a great thickness, so much so that if the figures were given, all would be greatly surprised at the amount of wood used in the construction. This enormous wooden hull is heavily plated with rolled iron plates, which cover the entire upper portion of the vessel, and extend 6ft. below the water line. The weight of this terrible armour is not far from 1200 tons. The bow of the vessel, for 50ft. abaft the stem, is of solid wood, with no space between the sides of the vessel, this being covered with iron, forming the most gigantic ram on record, having powers of resistance unequalled in every respect. The sides of this vessel, above the water line, are 7ft. thick and of solid wood, added to which is the heavy iron plating. This vessel has two rudders, one at each end, so protected that should one become disabled from any cause, the other can be easily used. The engines will give this vessel a very high speed, so that it is presumed when she strikes a vessel she would crash through her with perfect ease. Above the main deck the build is very peculiar, but at present cannot be described. In addition to a large casemate, containing heavy broadside guns, there will be two of Ericsson's revolving turrets, each containing two 15-inch guns. The naval register puts her armament down at ten guns, but it will be much larger. The accommodation for the officers and men are, it is stated, to be of a superior kind—large, airy, and as well ventilated as an ordinary ocean steamer, yet giving to them all the necessary security in time of action. In every respect she will be one of the wonders of the age. She is intended more particularly for harbour defences, but can readily go to sea, as she possesses all the qualifications for buoyancy, &c. She is intended to defy anything else in the shape of an iron-clad.

Federal Naval Experiments.—It is stated that Captain Ericsson has devised machinery by which four men can work a gun weighing twenty tons, in a turret. Another invention has also been tried, but without the same success—a contrivance for firing a 15in. gun inside a turret. To fire it outside the turret would require a port so large that a good marksman with a rifled gun could hit it nine times out of ten. Hence the necessity for some invention by which the huge gun could belch its thunders upon the enemy from the inside of the turret without filling it with smoke or creating a concussion so great as to endanger the lives of the gunners. To this end Captain Ericsson invented a peculiarly shaped box, but which was shattered to pieces in the trial, after three shots were fired, It is taken for granted, however, that the difficulty will be overcome in time, and that the *Monitors* will then be the most formidable vessels afloat, though it remains to be seen whether they may not be run down by a ram.

The Sutlej.—The trial of this frigate took place at Portsmouth on the 5th ult., and was attended with the most satisfactory results to all concerned. The ship first steamed as far as St. Helen's Roads, when her course was steered for the measured mile in Stokes' Bay, on reaching which the required runs were made at full and half boiler power, and circles made in the ordinary manner under full steam, as follows, the screw in use being a Griffiths, with a diameter of 17ft. 6in., and a pitch of 20ft., at full boiler power:—

No. of run.	Time. h. m.	Speed of Ship.	Revolution of Engines.
1.	4 45	12·631	68
2.	5 32	10·843	69
3.	4 32	13·235	71
4.	5 55	10·140	70
5.	4 26	13·533	70
6.	6 13	9·651	70

The ship's mean speed in the six runs was 11·808 knots. Two runs followed at half-boiler power, the first giving the ship a speed of 10·876 knots with the tide; and the second against the tide, and in the face of nearly half a gale, slightly on the starboard bow, of 6·101 knots; the mean of the two being a speed of 8·488 knots. Getting the steam up again to its full pressure, the ship was next tested in making complete circles to port and starboard, and in moving the engines to signal from the deck bridge. The helm was first put to starboad with 2¾ turns of the wheel, bringing the rudder to an angle of 19 degs., when the half circle was made in 3 min, 50 sec., and the full circle in 7 min. 42 sec. With the helm to starboard, and 2¼ turns of the wheel, bringing the rudder to an angle of 22½ degs., the half circle was made in 3 min. 42 sec., and the full circle in 7 min. 1 sec. Eleve n men were stationed at the wheel. At the conclusion of the circle trials the machinery of the ship was tested in its movements, in answer to the signal given from the ordinary iron rod and bevelled wheel telegraph of the upper deck bridge. From the time of moving the telegraph handle on the bridge, the engines were brought to a state of rest from full speed in 19 seconds. They were next turned astern, and full speed attained in 9 seconds; and from full speed astern to full speed ahead, only 24 seconds elapsed. The working of the engines and boilers was all that could be desired on every point. The weather was not the most desirable for developing the best steaming powers of the ship, as the wind, which was at a force of from 3 to 4 from south at the commencement of the runs at the mile, gradually increased until, as the full power trials drew to a close, it blew nearly half a gale, with the wind slightly backing to the eastward. This, of couse, had a very prejudicial effect upon the ship's speed, and especially in the two runs at half boiler power.

Naval Appointments.—The following appointments have taken place since our last. R. E. Ramsey, acting Second-class Assist. Engineer to the *Indus*, as supernumerary; J. Redgrave, acting Second-class Assist. Engineer, to the *Dromedary*; S. Madden, Chief Engineer to the *Indus* for the *Pelorus*; W. H, Houghton, acting Chief Engineer to the *Asia*, as supernumerary; C. A. Hobbs and R. Sampson, Chief Engineers to the *Asia*, for *Algiers* and *Arrogant*, respectively, when paid off; F. S. Turner, acting Second-class Assist-Engineer, to the *Indus*, for the *Valorous*; W. Vawdrey, acting Second-class Assist. Engineer, to the *Cumberland* for the *Conqueror*; J. Lambert and J. Horrocks, acting Assist. Engineers, to the *Niagara* and *Pylades*, respectively; W. M. Chambers, Chief Engineer, R. Winter, and A. Purvis, First-class Assist. Engineers, and J. A. Shawyer and J. Stout, Second-class Assist. Engineers, to the *Pylades*; F. Pursell, acting First class Assist. Engineer, to the *Cumberland*, for the *Spanker*; J. Runnalls, acting Second-class Assist. Engineer, to the *Indus*, as supernumerary; J. Langland, Engineer, J. B. Liddell, First-class Assist. Engineer, and J. Conolly, Second-class Assist. Engineer, to the *Shearwater*; T. Murray, Acting First-class Assist. Engineer, to the *Indus*, for the *Clinker*; R. Widdecombe, in the *Aboukir*, W. P. Ward, in the *Liffey*, J. R. Hancock, in the *Fox*, H. J. Wilson, and T. Cross, in the *Asia*, and A. Smart, in the *Pembroke*, to be First-class Assist. Engineers; J. Miller (a), in the *Mars*, J. Manhinnick, in the *Ariel*, A. J. Barton, in the *Wanderer*, and J. Phillips, in the *Clio*, to be acting First-class Assist. Engineers; S. Swift, Chief Engineer, to the *Asia*, for the *Neptune*; J. A, Barton, Chief Engineer, to the *Cumberland*, for the *Amphion*; J. Downe, Engineer, to the *Indus*, for the *Sriton*; J. Jroine, Acting Engineer, to the *Indus*, for the *Partridge*; H. G. Burr and W. Harvey, Acting Second-class Assist. Engineers, to the *Cumberland* and *Indus* respectively, as supernumeraries; C. Jeely, Chief Engineer, to the *Cumberland*, for the *Scylla*; W. Bremner, Second-class Assist. Engineer, to the *Cumberland* as supernumerary; T. Owen, Acting Second-class Assist. Engineer, to the *Indus*, for the *Prospero*.

MILITARY ENGINEERING

Armstrong and Whitworth Guns.—Some additional experiments have taken place at Shoeburyness, with 12-pounder Armstrong guns, fired against Mr. Scott Russell's target. A new form of round-fronted shot, recently produced by Sir W. Armstrong, was used, and, with the ordinary charge, penetrated much deeper than the Whitworth shot. On the 3rd ult. the target fired against by the Whitworth shells, and the timber backing of which was said to have been completely shattered by the explosion underwent an examination, and it was found that no serious injury to the timbers beyond what usually arises from the shock of firing had taken place. A fragment of one of the iron plates was driven into the backing, but the injury spread no further; and it is asserted by artillery officers present that, as an explosive missile, the Whitworth shell has thus far done no material injury to the timber backing of the target.

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LONG AND SHORT PROJECTILES.—Since the ordnance stores have been filled with long lead-coated shot sufficient to last for several years—if they can be made to keep without deterioration from galvanic action—it is said to have been discovered that short shot are the proper thing. Lately projectiles weighing from 50lb. to 68lb., instead of 110lb., have been fired from the 110-pounder guns at Shoeburyness, and a velocity of from 1550ft. to 1600 ft. per second obtained by increasing the powder charges. This is, however, still below that of the 68lb. shell, which has a velocity of 1810 ft. per second, while the solid ball from the same gun has a velocity of 1580 ft. per second, with the very large windage of two-tenths of an inch—but will the fine grooving stand the strain due to the increased velocity given to the short projectile?

SOLID DRAWN GUN BARRELS.—On the 2nd ult., by the permission of the court of the company, some very interesting experiments were made at the proof-house of the Gun-makers' Company, Whitechapel, on a fowling piece and rifle barrel made by the new process of solid cold-drawing, of which Messrs. Christoph, Harding, and Hawksworth, are the patentees. By this process the metal is drawn cold by means of the hydrostatic ram, and thus a saving is effected to the extent of one-half the metal now consumed by the hot process. For instance, about 10lb. of metal is now used in making an Enfield rifle barrel, which when made weighs only about 4½lb., the remainder of the metal being consumed in the manufacture. By the present process two rifle barrels can be drawn from the same amount of metal, equally strong in every respect to those now made. The barrels tried were drawn from a new kind of cast steel and subjected to the following proofs:—

Rifle Barrel.

First proof.....	7½ drachms of powder 2 wads 1 ball af 510 grains	No effect
Second proof.....	Same powder 2 balls.....	No effect
Third proof.....	10 drachms of powder 3 balls.....	Ditto.
Fourth proof.....	15 drachms of powder 5 balls.....	Ditto.

The fowling piece was put to the following proofs:—

First proof	10¼ drachms of powder 2 wads One round ball of 14 to the pound.....	No effect
Second proof.....	Same powder 2 wads 2 round balls.....	No effect

It was then determined to burst this barrel by putting in a proof charge and two balls, then cramming the muzzle of the barrel to the extent of two inches with moist clay. The result was that the barrel burst at the bottom of the clay, only tearing off about two inches of its length, and showing no other signs of injury. A similar barrel, proved at Birmingham, only slightly bulged, with 20-drachms of powder and three balls. Several specimens were also exhibited, showing the applicability of this process to drawing hollow tubes in iron or steel of any shape, and almost any reasonable length.

NEW DEFENCES AT PORTSMOUTH.—Some hundreds of men are employed at Portsdown-hill in the construction of an important line of forts, extending from Bedhampton to Fareham, by Farlington, Parbrook, and Crookhorn, three forts forming a triangle, and connected together by galleries, parapets, and ditches, excavations only being as yet made under the first contract; and by Windmill or Widley fort, where brickwork as well as excavations are in progress; by Southwick fort, the most elevated of the whole series, and the one most immediately opposite the dockyard, and which, as well as the next at Widley is vast developing its extent and form; by Nelson fort, which is being erected at the Obelisk; and next by Fort Wallington, which crosses fire with Fort Fareham on the opposite side of the creek. Fort Wallington is a work of great strength and extent. Fort Fareham is included in this line of forts as a defence to Portsdown on the west. Widley, Southwick, and Nelson forts, which are contracted for by Messrs, Treadwell, will be supplied with water from one reservoir formed at Southwick. The six first mentioned contracts do not include barracks and other works, but the plans are complete. The revetments of all the ditches will be of chalk masonry and flint.

STEAM SHIPPING.

THE STEAMSHIP "GREAT EASTERN."—Mr. C. H. Haswell, of New York, has addressed the following letter to Messrs. Howland and Aspinwall, upon the subject of the repairs to the *Great Eastern*, rendered necessary in consequence of the last accident to this vessel:—"New York, December 3rd, 1862.—Gentlemen,—In conformity with your request, I yesterday visited the steamship *Great Eastern*, anchored off White Stone, for the purpose of examining the nature and extent of the injuries received by her in her late collision with a submerged rock, and the character of the repairs rendered necessary and in progress in consequence of that collision—and having discharged this duty, I submit the following report —Upon my arrival I examined the hull externally above water and within board, to ascertain if it gave evidence of any unresisted stress since my survey of her upon a previous voyage. Having satisfied myself upon this point, I descended from without the hull to within the coffer inclosing the rupture in her botton, and also from within the hull between the outer and inner plating, again to down to the place of rupture, being by this proceeding enabled to examine the full extent of the injuries to the bottom of the hull covered by the coffer and the character of the repairs being made thereto, and upon a full consideration of the elements presented, I am of the opinion: 1st—That the effect of the collision is restricted to a partial crushing of two of the webs and rupture of some of the outer plates of her bottom, upon the port side, and that the hull of this vessel—beyond the points of rupture, above water and within board—is in no wise injured by the collision. 2nd—That the repairs to her bottom, so far as made, have been executed in a manner to restore it to its original security as to leaks and reistance to stress, and that the design both of the method of effecting these repairs and the manner of executing them, reflect high credit to all concerned. In connection with this, it is proper to refer to the construction of the bottom of the vessel, in order that it may appear how peculiarly adapted it is to meet an injury like that which has occurred to it. Thus, the bottom is composed of an outer and inner plating of equal thickness, with an intervening space of thirty five inches, the connection between the platings consisting of thirty-two webs or keelsons running fore and aft, and thirteen athwart ships, whereby the bottom is divided into a series of apartments or cells, the communication between them being at command, and from within board by the use of man-hole plates. In the event, therefore, of the outer plating alone being ruptured, as in the present case, the inner plating will resist the admission of water within the hull, and the cellular structure of the whole will resist the admission between the platings, beyond the limits of the cells inclosing the rupture. In communicating the result of my survey to the Underwriters here, and to Lloyd's, London, I shall report her seaworthiness—provided the repairs now in advanced progress are completed—to be of the same character as before the collision which has involved them."

THE AMERICA screw, intended for the Nordentschen-Lloyds, of Bremen, has been launched from the yard of Messrs. Caird and Co., of Greenock. She is of 2500 tons, and is the fourth vessel of the same size built by this firm for that company. The *America* is 360ft. in length, 40ft. breadth of beam, and 34ft. depth of hold. She is to be fitted with a pair of inverted cylinders, direct acting engines of 500-horse power, nominal, capable of being worked up to 1800-horse power. Messrs. Caird have besides on the stocks another steamer of the same dimensions for the Hamburgh and American Steam Packet Company, a mail steamer for the London Brighton and South Coast Railway Company, and five paddles for the home trade.

THE "ELECTRIC," screw steamer, intended to ply between Belfast and Liverpool, was recently launched from the yard of Messrs. Todd and M'Gregor, of Glasgow. Her dimensions are—length 210ft., breadth of beam 27ft. Another steamer, similar to the *Electric* and intended for the same trade, will soon be completed by Messrs. Todd and M'Gregor

THE "PALERMO," screw steamer, of 409 tons register, the property of Messrs. Florio and intended for the Sicilian and Italian trade, has been launched from the building yard of Messrs. Scott and Co., Cartsdyke. Her engines, which will be of 140 horse-power, will be supplied by the Greenock Foundry Company, The *Palermo* is nearly similar in size to the *Etna* and *Campidoglio*, recently launched by the same firm and for the same owners.

THE "UNDINE YACHT."—This handsomely fitted-up steamer, belonging to the Duke of Sutherland, recently fitted with engines by Messrs. Jas. Watt aad Co., made a trial trip down the river on the 1st ult., for the purpose of testing her speed by the measured mile. The following is the result as registered by Troddam's tables:—1st trip in 5 min., 35 sec.; 2nd in 5 min., 38 sec.; 3rd in 4 min., 46 sec.; 4th in 4min., 49 sec.; 5th in 6 min,, 36 sec.; 7th in 7 min., 4 sec.

TELEGRAPHIC ENGINEERING.

TELEGRAPH FEAT.—The wonderful feat of writing by telegraph direct through a continuous line of 3500 miles, has beem achieved in the United States. Between 4 and 5 P.M., a news message was sent to San Francisco, to which, a few minutes afterwards, a return message was received, dated San Francisco, Nov. 6th, 2½ P.M., was answered at 2 P.M., or three hours before it was sent, in the usual order of time. The difference in time between the two cities is three hours and fourteen minutes.

TELEGRAPH TO AMERICA.—Another attempt is being made to raise the necessary capital for testing the great experiment of uniting this country with America by means of submarine telegraph. It appears, also, that the directors have received a tender from Messrs. Glass, Elliott, and Co., who agree to make and lay a cable from Ireland to Newfoundland on conditions peculiarly favourable to the company.

SUBMARINE CABLES.—The Gutta Percha Company have recently published a list, which shows that fifty-one submarine cables have been undertaken between 1851 and 1862, and that the entire number, with the exception of seven, are at present in good working order.

THE TELEGRAPH TO INDIA COMPANY.—At a meeting recently held of this company the report was unanimously adopted. The Indian Government have determined to construct a line from Bagdad to Kurrachee. The Company's line between Jubal and Alexandria continues to work most satisfactorily. The Indian Government refused the application for a guarantee to enable the Company to establish a new Red Sea line. The directors, therefore, recommend the Company to continue to work the land line in Egypt, and the cable between Suez and Jubal, retaining the firman's instruments and other property in Egypt, as in the event ot the Bagdad line proving inadequate to the requirements, or from any other cause which shall indicate the need of an alternate means of communication, the company would no doubt receive the cordial support of Her Majesty's Government and of the public in continuing the line. The 200 miles of cable which was expected shortly to arrive will be disposed of at once.

RAILWAYS.

RAILWAY CHAIRS.—Mr. Antonio Gabrielli, of Turin, proposes an improved wrought-iron chair for securing rails. The chair is composed of two-wrought iron plates, one overlying the other. The under plate is made rectangular, and forms the base of the chair, and the upper plate, which is smaller, lies across it diagonally, but so that its extremeties extend to the ends of the base plate. These plates are connected together by a central bolt, which forms a pivot far them to turn on. The central bolt is driven into the wooden sleeper. The jaws of the chair are formed by turning up portions of the sides of the two plates, Iron clamping pieces are used between the rail and chair.

IRON RAILWAY CARRIAGES.—The Pennsylvania Railroad Company are having iron cars constructed for use on their road. It is supposed that they will be much lighter and stronger than wooden cars, last much longer, and be much more secure from accident.

RAILWAY ACCIDENTS.

ACCIDENT ON THE GREAT EASTERN RAILWAY.—A serious accident on the morning of the 7th ult., took place on the Great Eastern Railway, by which considerable damage was inflicted on the permament way and rolling stock. The train which leaves Hertford at 1 a.m., and is due at Shoreditch at 9.30 a.m., had scarcely got upon the main line when the engine left the rails, carrying with it the tender and several of the carriages. All the up-traffic was interrupted for a long time. To prevent any collision between the disabled train and the express from Norwich, which was due in about half-an-hour or twenty minutes, men were sent forward with danger signals, at the sight of which the driver of the express promptly brought his train to a standstill.

FALL OF A RAILWAY TUNNEL.—Twelve or fifteen yards of the end of a tunnel at Oakenshaw, on the Cleckheaton branch of the Lancashire and Yorkshire Railway, fell on the morning of the 23rd ult., completely blocking up the passage. A mail train from Mirfield, which should have reached Bradford at a quarter before six in the morning, ran into the midst of the rubbish. The engine was firmly embedded, but the passenger carriages were soon backed out. There was no loss of life, or other serious personal injury. A common road crossed the portion of the tunnel which fell in.

COLLISION ON THE GREAT NORTHERN RAILWAY.—A collision, involving serious injury to several passengers, and a great loss of property, happened on the afternoon of the 24th ult., at the Barnet Station of the Great Northern Railway. According to the particulars, it appears that about four o'clock on the above afternoon, a coal train was being shunted out of the siding on to the main line, but what precautions were taken to protect the road while this work was being performed by putting on the auxiliary signal has not transpired. It would seem that the shunting was going on when the up-express train from the north, due at King's-cross about a quarter-past four, was heard coming up at its usual rate of speed, not having to stop at the station. The obstruction was observed by the driver of the engine, but the distance was not sufficient to enable him to bring up before dashing into the coal waggons. To add to the difficulties, there is a descent in the line approaching Barnet from Potter's Bar of 1 in 200, and being Christmas Eve the train was unusually heavy. The shock of the collision is described as having been very great. The coal waggons were thrown high over each other across the line in great confusion, bringing down a foot-bridge erected over the railway, and ploughing up the permanent way. The speed of the passenger train had been somewhat reduced, but the force with which it came in contact with the coal waggons, caused the engine and tender to leave the metals, occasioning an alarming crash among the carriages and serious injury to several of the passengers. As the coal waggons were thrown over in such a way as to entirely block up the line, the most prompt measures were taken to warn the approaching up and down trains. Gangs of labourers were set to work to clear the road, but it was some hours ere the traffic could be resumed, occasioning the greatest inconvenience to the travellers leaving King's-cross and those bound to London.

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Accident near Hereford.—On the morning of the 25th ult., an accident occurred on the Merthyr and Brecon railway, by which one life was lost and several persons seriously injured, some of whom were not expected to recover. It appears that several workmen hurriedly got into some empty trucks at the commencement of a steep incline, without attending to the break. The waggons started off down the incline at great speed; the foremost was thrown off the rails, and the others coming along, a concussion ensued, and the whole were shattered to pieces, the occupants being thrown about in all directions.

BOILER EXPLOSIONS.

Fatal Boiler Explosion at Oldham.—On the 16th ult., a serious boiler explosion took place at Messrs. Evans, Barker, and Co.'s Hartford Colliery, Lyon Dam, Oldham. A man, who was employed by the engineer to do "little jobs" for him, such as clearing away the ashes from about the boiler furnace, was blown down by the force of the shock, and covered by the *debris* of the shed. The end of the boiler was driven completely out, and the furnace door torn off, as well as the brickwork destroyed.

Boiler Explosion.—On the 16th ult., an explosion occurred at Carn Brea Mine, by the boiler attached to the stamps-engine bursting with great violence. One man, carpenter of the nine stamps, was killed, and several others were severely injured. Carn Brea Mine is the property of a company, and is one of the most extensive, as well as productive, tin and copper mines in the county. It has no less than fourteen large engines connected with it, rearing their immense shafts and flywheels over an extended district. One of these engines is known as the stamps engine; it is of great power, being 32 inches in the cylinder. It is worked by means of four horizontal boilers, placed side by side. It was the most easterly of these which exploded about half-past eight o'clock, in the morning, with a noise so great that it was heard all over the neighbourhood.

Boiler Explosion near Baxenden.—On the 19th ult., a boiler explosion occurred about half-past three in the afternoon, at the small factory occupied by Hargreaves and Bateson, Rising Bridge, near Baxenden, by which three boys lost their lives. The boys were playing in the boiler-house when the explosion took place, and by all appearances they were scalded to death. The cause of the explosion has been attributed to the fact that the under part of the boiler had collapsed, and that the steam had forced its way out by the flue.

Boiler Explosion at Masborough.—On the morning of the 3rd ult., an explosion of a boiler took place at Messrs. Beatson and Co.'s Midland Ironworks, Masborough, near Sheffield, by which seven lives were lost and a number of persons seriously injured, and also a vast amount of injury done to property. The rolling mill occupied a large space in the centre of the works, and it was in this part that the calamity took place. Several boilers, of various dimensions, were fixed in the mill, to furnish the power necessary to work the large number of rolls that are in use. One of these boilers, nearly the largest in the place, was embedded midway between two smaller ones, at about 80 yards from the entrance gate. Behind the boiler, looking westward, was a large space unroofed, occupied by vast heaps of refuse. Beyond these was the boundary of the works on that side—a large green field leading to the Fern, the residence of Mr. Beatson. Eastward, the space was occupied by a large number of puddling furnaces, rolls, and engines, the machinery attached to the latter being of the most ponderous description. The roof of the shed was partly sheet iron and partly slate, and the supports were wooden and iron beams, crossed upon very large iron pillars. Near the boiler were two enormous chimneys, into which the flues from the several of the boilers and furnaces were conducted. A few minutes after seven o'clock in the morning, there were about 150 men and boys employed in the shed, when a loud report was heard, the large boiler was launched forward into the mill, and in an instant the whole place was in ruins. The two huge tubes of the boiler were projected with immense force to the rear of the premises, on to the open space mentioned above, being accompanied in their flight by showers of red-hot bricks from the bed of the boiler, slates and sheets of iron from the roof of the shed, and other portions of the *debris* which covered the whole space around. The boiler itself was launched forward with inconceivable force, right into the body of the rolling mill. Before this missile everything went down like so many reeds. The supports of the roof were broken—solid iron columns of 12in. or 14in. thickness snapping short off, as if they had been made of glass. An immense fly-wheel of solid iron, the metal being the thickness of a man's body, was broken in two places, and a cog-wheel of even larger size was also instantaneously snapped asunder by the force of the blow. The exterior of the mill also bore numerous and serious traces of the force of the explosion and the extent of the destruction. One of the mill chimneys, a solid structure of 130 feet high, was "scarred" from the bottom to the summit with the marks of the blows it had received from the bricks and fragments of iron and machinery, which were shot up from below. The damage to the works is estimated at £3,000, but a much greater loss will be occasioned by the stoppage during the winter months.

Boiler Explosion near Alnwick.—An accident recently occurred at Rock Moor House, a farmstead in Northumberland, and situated near Alnwick, by the explosion of a boiler attached to a thrashing machine. The explosion took place during the dinner-hour, and when nearly twenty persons were warming themselves at the furnace. Six were killed on the spot, and others fatally hurt.

The Manchester Association for the Prevention of Steam Boiler Explosions.—At the ordinary monthly meeting of the Executive Committee of this Association, held on November 25th, 1862, the Chief Engineer presented his monthly report, of which the following is an abstract:—"During the past month there have been examined 365 engines and 547 boilers. Of the latter, 8 have been examined internally, 60 thoroughly, and 479 externally, in which the following defects have been found:—Fracture, 5 (1 dangerous); corrosion, 38 (3 dangerous); safety-valves out of order, 13; water gauges ditto, 31; pressure guages ditto, 9; feed apparatus ditto, 6; blow-off cocks ditto, 47 (1 dangerous); fusible plugs ditto, 3; furnaces out of shape, 6 (2 dangerous); blistered plates, 3; deficiency of water, 1. Total, 162 (7 dangerous). Boilers without glass water gauges, 10; without pressure gauges, 2; without blow-off cocks, 38; without back pressure valves, 78. An explosion has occurred this month to the boiler of a first-class passenger locomotive engine, by which three persons were killed and others injured. It was considered to be perfectly safe, had been on duty the previous day, and was being cleaned ready for work at the moment the explosion occurred. It will be remembered that reference was made in the July, 1861, report, to another explosion of a locomotive boiler, which took place while the train was running; and since that time three others have occurred in additon to the one first alluded to, thus making five during that period with this class of boiler. The cause of explosion in four of these cases proved to be thinning of the plates from internal corrosion. I have only had an opportunity of examining the plates of one of these exploded boilers, but from official reports, it appears that the corrosive action had developed itself in a very similar manner in each instance, which in the one personally examined was as follows:—The corrosion had eaten grooves or furrows parallel with and close to the edge of the overlaps of the plates, at some of the longitudinal seams of rivets; the furrows being on the outer plates of the overlap, while the deepest one, and that from which the explosion had sprung, was situated nearly midway between the smoke box and fire box. This furrowing action will be at once recognised by those who have been in the habit of observing the influence of wear upon the ordinary internally fired double-flued boiler, in general use in Lancashire. In this description of boiler the furrow is found on the inner surface, both of the front and back end-plates, but more especially at the front, and lies close to the edge of the internal flue angle-iron, which it partially encircles; the furrow being deepest at the crown, and gradually dying out in about six or nine inches on each side. It is sometimes found in the root of the angle-iron itself; the choice of position between the plate and angle-iron, apparently depending upon their comparative power of resistance. When the plate of the furnace-tube is flanged, the furrow more frequently occurs at the springing of the flange than at the end-plate. Furrowing also is very commonly found at the transverse seams of rivets at the underside of boilers; the furrows in these cases being immediately at the edges of the overlaps, and most frequently on the external surface of the plates, but sometimes on the internal. This action is more severe in long boilers than in short ones, and at the middle of their length rather than at their ends. It is seldom, if ever developed at the longitudinal seams of these boilers, except where leakage takes place, and is then found to be most severe when the objectionable plan of construction is adopted, of placing the seams of rivets in one continuous line from one end of the boiler to the other. Such are some of the manifestations of furrowing constantly met with in the boilers under the inspection of this Association, and it may be interesting to attempt to trace the cause. Furrowing appears to be the result of corrosive and mechanical action combined. The mechanical action, such as an alternate buckling of the plates, strains and frets them, and thus renders them more susceptible to the influence of corrosion than the parts at rest. Where these furrows are internal, the corrosive element is furnished by the water, which is rarely, if ever, free from acidity; and when the furrows are found externally in the flues, as explained above, the corrosion may perhaps be attributed to the influence of the gases. The cause of the buckling action varies according to the position in which it occurs. In the stationary boilers above referred to, when found in the front end plate, it may be ascribed to the alternate elongation of the internal flues, more especially at the furnace end; and, when at the bottom of the external shell, to the unequal expansion of the plates consequent upon the different strata of temperature in the water. The temperature of these strata varies with the distance from the bottom of the boiler, in proof of which it may be stated that it is frequently found that while the water is boiling on the surface, that, at the bottom of the boiler it will not scald the hand. Those boilers are most conducive to this inequality of temperature which have a defective circulation of water, are so set that the last heat from the fires passes beneath them, and fed with comparative cold water introduced at the bottom. It will be readily seen how these varying temperatures induce unequal expansion of the plates, and thus put upon the seams of rivets most irregular and severe strains. In this way, it is thought that the buckling action is produced, which results in furrowing at the bottom of stationary boilers. In locomotive boilers, the buckling at the longitudinal seams, in the cylindrical portion of the shell, arises from its not being of true circular form in the vicinity of the overlaps. The tendency of the internal steam pressure is to correct this, and to induce a true circular form, and thus a cross strain, which may be correctly termed a 'girder strain,' is put upon the plates at a short distance on each side of the line of rivets; from this a change of shape ensues, which constantly varies with the pressure of steam. The position of the furrows is found to be that of greatest elasticity, being midway between the fixed ends of the fire box and smoke box, just where the buckling action would have most play It will at once be seen that the thicker the plates, the greater the leverage of the girder action, and thus to thicken their edges is only to aggravate the evil. The true circular shape may be maintained, as far as appearance is concerned, by substituting a butt-strip for the overlap, but this, from its one-sidedness, will not prevent the girder action, and, indeed, tends to make two furrows instead of one. Were an inner as well as an outer butt-strip introduced, the parts would be in equilibrio, and the strain then passing through the centre of the plates, they would be subjected to their legitimate tensile strain only, and the buckling action in question set at rest."

ACCIDENTS TO MINES, MACHINERY, &c.

Colliery Explosion near Barnsley.—On the 8th ult., shortly before eleven o'clock, an explosion of fire damp took place at the Edmund's Main Colliery, which was attended with a very serious loss of life. The colliery, which is about 180 yards deep, and in which the Barnsley bed of coal has been principally worked, has been hitherto nearly free from accidents involving the loss of life, the proprietors, Messrs. Bartholomew, Tyas, Mitchell, and Co., having adopted every means for the safety of the men. At the time stated the men in the pit, numbering close upon 300, were startled by an explosion of fire damp, which caused those near the pit bottom to at once make to that spot for safety; those in the advanced levels, some 1400 or 1600 yards distant, were unable to reach it in consequence of the gas. The men at the top were soon made acquainted with the state of affairs by the quantity of coal and rubbish thrown up out of the cupola by the explosion. Assistance was promptly obtained, and as the news reached the other collieries in the neighbourhood the men at once ceased working and rushed to the scene of the catastrophe. Plenty volunteered to descend and rescue, if possible, the men below. In this they were so far successful that in a short time some 40 or 50 were brought to the pit mouth, about 20 of whom were burnt severely, some fatally. The bottom steward also went down, and was obliged to be left by the party he went with, having evidently penetrated too far into the workings and been overcome by the sulphur. Shortly after two o'clock it was announced that nothing more could be done until bratticing was fixed and the air-course was cleared. An investigation made by several mining engineers showed that there was no hope of rescuing the men, of whom there were supposed to be 53 in the pit. Preparations were then at once made to let the water from the canal flow into the pit, so as to extinguish the flames.

GAS SUPPLY.

Gaslight in Railway Trains.—The system of lighting railway carriages with gas, according to Newall's patent has been introduced upon the Scottish Central Railway. The first gas-lit train left Edinburgh on Monday evening, the 8th ult., for Perth, the whole of the carriages being brilliantly lighted by means of pipes (with expanding couplings carried from roof to roof) communicating with the reservoir placed in a specially-constructed compartment of the guard's break-van. Throughout the journey the lights remained perfectly steady and clear, and the passengers were much gratified with the successful introduction of this vastly superior method of illumination. Should the present trial be satisfactory, it is expected that the system will be extended to the other night trains on the line, and probably introduced on the neighbouring railways.

Atmospheric Gas.—The apparatus by which the atmospheric gas, as it is termed, is manufactured is stated to be very simple. A carburator saturates atmospheric air (which may be forced through it by any means, provided a regular supply be kept up) with an inflammable vapour, and the same result would probably ensue whether benzoine, naphtha, or any similar liquid were used. The apparatus consists of two chambers, the upper containing the principle body of liquid, and the lower a smaller quantity to saturate the air with. The liquid in the lower chamber is kept at an uniform height by a tube and valve, or other means. The lower chamber is completely filled with wicks, which are kept saturated by capillary attraction. The air passes through these wicks, and not through the liquid, and licks up so much of the inflammable vapours as to become capable of ignition.

Gas Lighting in Paris.—Several landlords in Paris have recently assumed a right to prohibit their tenants from using gas, not only in the upper part of the houses, but in the shops on the ground floor. The Court of Cessation has recently decided that the custom of lighting by gas having become almost universal, every landlord must be taken to have consented to its use in the absence of any express stipulation to the contrary.

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THE ILLUMINATING POWER OF CITY GAS.—In the report presented by Dr. Letheby on the illuminating power of the gas supplied to the city of London during the Autumn quarter, by the Great Central Gas Company, the Chartered, and Commercial gas companies, the following is found. That the mean illuminating power of the Great Central gas was equal to 13·34 sperm candles of the standard quality, and that of the Chartered to 13·78 candles, and that of the commercial to 13·02. The weekly average of the Great Central had ranged 12·69 to 14·93, and that of the Commercial from 12·41 to 13·85. The difference on the mean illuminating power of the Great Central gas at the two places where it has been tested, namely, at Finsbury Square and the London Hospital, which are nearly two miles apart, differed only to the extent of 0·45 of a candle, and as the largest average (13·35) was at Finsbury Square, it was manifest that the difference was accidental. These results indicate that the gas supplied in the city by the three companies has not, during any week, been below the standard quality, and that the quarterly averages have been from 8·5 to 0·15 per cent. above it. The former is the excess of the Commercial average, and the latter of the Chartered; that of the Great Central having been 13 per cent. over the standard.

INFLAMMABLE GAS AIR.—Mr. S. E. Turner, of Birkenhead, has patented an invention which relates to an apparatus for burning a mixture of inflammable gas and air, now in use, wherein the inflammable gas escapes from a jet placed inside a cylinder open at the bottom, and covered at the top with a diaphgram of wire guage, or finely perforated plate, so that atmospheric air enters the bottom of the cylinder, and, mixing with the inflammable gas issuing from the jet, assists the combustion of the same, which takes place on the top of the diaphgram. To render the combustion in such an apparatus more perfect, one or more metal tubes are introduced into the bottom cylinders wherein the mixture of the gas and air takes place; such tubes are open at the bottom, and pass up through the gauze into the combustion chamber. By this means the atmospheric air is used in a highly heated state, and the combustion, adds the specification, is much more nearly perfect.

THE CARBURATION OF GAS.—The following is an outline of the specification drawn up by Dr. Letheby for the quality of the naptha to be supplied to the carburators (nearly 2000 in number) of the City lamps. The particulars of the specification have been arrived at by a long series of experiments with naphthas of different densities and boiling points: The naphtha must be colourless, and of a gravity not less than 830, nor greater than 860. When placed in a distillation apparatus in a bath of oil, and having a thermometer placed in the naptha, it must begin to distil at a temperature not higher than 110° C. (230° F.), and must yield 70 per cent. of volatile naptha at from 110° C. to 130° C. (266° F.), and 20 per cent. between 130° C. and 150° C. (302° F.). This is expected to leave but little residuum, and to give continuously 8 grains of hydrocarbon to each cubic foot of gas, and thus raise the illuminating power of the gas about 60 per cent. over that unnaphthalised.

REPORT ON GAS LAMPS IN THE CITY OF LONDON.—The engineer and officer of health to the City Sewers Commissioners, have reported to the commissioners on the subject of gas consumption in the street lamps, including the question of meters and of carburation. The result is, that both light and economy would be promoted by the use of a meter to every street lamp, notwithstanding the probable expense of renting meters, and that carburation is also an improvement where naphtha of good quality and in sufficient quantity is used. The United Kingdom Carburating Gas Company, whose patent process has been used, state that it produces equal light with half the ordinary consumption of gas. The reporters, however, find this to be above the actual average, but they still speak of a saving of from 25 to 75 per cent., and of £1 per lamp per annum.

THE YORK GAS COMPANY, between whom and the public and Corporation, there has been much dissatisfaction on account of the high prices charged, have agreed to reduce their charge for public lamps from 4s. 9d. to 3s. 9d. per 1000 cubic feet, the price to include all other charges. To private consumers the charge is to be—present year: 3s. 9d.; and from and after January, 1864, 3s. 6d. per 1000 cubic feet, instead of 4s. 6d. hitherto paid.

MINES, METALLURGY, &c.

IRON ORE.—Particulars have been recently given with respect to the pig iron and coal production of the United Kingdom. It may now be added that Mr. Hunt estimates the amount of the iron ore made available in 1861 at 7,215,518 tons, of the computed value of £2,302,371. Of this amount Cornwall contributed 26,262 tons, of the value of £8372; Devonshire, 5390 tons, of the value of £2159; Somersetshire, 32,763 tons, of the value of £16,381; Gloucestershire, 100,419 tons, of the value of £45,189; Wiltshire, 55,779 tons, of the value of £26,493; Hampshire, 4007 tons, of the value of £1706; Oxfordshire, 5600 tons, of the value of £2100; Northamptonshire, 113,139 tons, of the value of £23,534; Lincolnshire, 33,559 tons, of the value of £13,403; Warwickshire, 15,250 tons, of the value of £4000; North Staffordshire, 499,195 tons, of the value of £174,711; South Staffordshire, 727,500 tons, of the value of £227,342; Shropshire, 223,400 tons, of the value of £48,403; Derbyshire, 396,520 tons, of the value of £99,130; the North Riding of Yorkshire, 1,130,760 tons, of the value of £169,368; the West Riding of Yorkshire, 235,500 tons, of the value of £58,875; Lancashire, 519,180 tons, of the value of £259,500; Cumberland, 472,195 tons, of the value of £259,680; Northumberland and Durham, 10,750 tons, of the value of £3000; North Wales, 86,500 tons, of the value of £22,425; South Wales, 542,705 tons, of the value of £172,287; Scotland, 1,975,000 tons, of the value of £658,333; Ireland, 165 tons, of the value of £66; and the Isle of Man, 967 tons, of the value of £816. Ore, although scarce in the Isle of Man, would thus seem to be of extremely high quality.

COAL.—Mr. Hunt estimates that 83,635,214 tons of coal were raised in the United Kingdom during 1861. Of this amount Durham and Northumberland, with 274 collieries, contributed 19,144,985 tons; Cumberland, with 28 collieries, 1,255,644 tons; Yorkshire, with 397 collieries, 9,374,600 tons; Derbyshire and Nottinghamshire, with 180 collieries, 5,116,319 tons; Leicestershire, with 11 collieries, 740,000 tons; Warwickshire, with 16 collieries, 647,000 tons; Staffordshire and Worcestershire, with 580 collieries, 7,253,750 tons; Lancashire, with 373 collieries, 12,195,500 tons; Cheshire, with 39 collieries, 801,570 tons; Shropshire, with 66 collieries, 829,750 tons; Gloucestershire, Somersetshire, and Devonshire, with 112 collieries, 6,514,025 tons; Wales, with 398 collieries, 8,661,021 tons; Scotland, with 424 collieries, 11,081,000 tons; and Ireland, with 46 collieries; 123,070 tons. The coal production of the empire appears to have largely increased during the last eight years. Thus in 1854, with 2,397 collieries worked, 64,661,401 tons of coal were raised; in 1855, with 2,613 collieries, 64,453,079 tons; in 1856, with 2,829 collieries, 66,645,450 tons; in 1857, with 2,967 collieries, 65,394,707 tons; in 1858, with 2,958 collieries, 65,008 649 tons; in 1859, with 2,949 collieries, 71,979,765 tons; in 1860, with 3,009 collieries, 84,042,698 tons; and last year, with 3,052 collieries, 83,635,214 tons. Of this vast quantity, only 7,560,758 tons of coal, 286,150 tons of coke, and 73,717 tons of patent fuel were exported, the remainder being absorbed at home. France was, in 1861, our best customer for coal, having taken 1,436,160 tons (in 1862 the exports in the same direction have been somewhat reduced, in consequence of the use of French coal for the Imperial navy); Denmark came next, with 542,567 tons; Hamburg, 514,427 tons; Prussia, 439,096 tons; Italy, 417,629 tons, Spain and the Canary Islands, 403,238 tons; America (Atlantic ports), 349,931 tons; Russia (northern ports), 342,513 tons; the foreign West Indies, 262,932 tons; Holland, 262,868 tons; Sweden, 214,004 tons; British India (continental territories), 199,069 tons; Turkey, 174,698 tons; the British North American colonies, 165,824 tons; Brazil, 157,281 tons; Norway, 135,221 tons; the British West Indies, 127,768 tons; Malta, 115,731 tons; Portugal, the Azores, and Madeira, 108,794 tons; and Hanover, 100,312 tons. Our other foreign customers took less than 100,000 tons each.

MINING BY MACHINERY.—An improved mining machine is at present at work at the Claxton Quarry, Grateshead, and appears to give complete satisfaction. It is manufactured by Messrs, Hawks, Crawshay, and Co., and said to be the invention of Captain Penrice, by whom it was submitted to the English and French Governments during the Russian war. The ventilation is kept up by suction, through a pipe, outwards instead of by the ordinary method of forcing the air in. A tube is carried along the top of the tunnel, at the head of which a partial vacuum is formed, the vacuum being refilled by the air which rushes into the tunnel. This tube is the chimney of the boiler, and the exhaust steam of the engine being driven into it, the ventilation is increased by this means also. The ash-pan is closed, an air-pipe is carried forward from it to the head of the bore, so that all the air drawn through the furnace by the exhaust of the engine and the suction-fan is taken direct from the inner end of the funnel, where it is replaced by fresh air from the exterior, and a very strong draught is created. The heat from the boiler is confined by means of water-tanks, which cover the surface of the boiler; and as there is a thick lining of felt between the boiler and the water-tanks, the constant supply does not at all interfere with the generation of steam. In Captain Penrice's machine a number of large chisels are inserted in the radial arms of a circular piece of metal, which is made to revolve, and at the same time to strike the face of the rock very rapidly. The advantage of the rotary motion is that the chisels are always chipping against an edge as they revolve. These blows are delivered at the rate of from 400 to 500 a minute, by a mass exceeding 9 tons in weight. The debris falls to the ground, and is carried off beneath by rakes attached to an endless chain; and so admirable is the action of the machine that 12ft. of tunnel can be, and has been, made in 33 hours. Under these circumstances there certainly appears to be full justification for the statement that the machine is constructed upon sound principles, and is of great practical value. It has been found that the ventilation is so perfect that with a boiler in the place, working at 120lbs. to the inch, the temperature did not exceed 60° Fahr., so that there could be no inconvenience from excessive heat. A company under the name of the Patent Steam Tunnelling and Mining Machine Company has been formed for developing this invention.

MELTING STEEL IN LARGE MASSES.—Mr. Alfred Indre, of Paris, has discovered that by covering steel with bottle glass, or the slag of a charcoal smelting furnace, it may be melted in a reverberatory furnace easily and rapidly, and without losing any of its qualities. Two tons may be melted at once in the same furnace. Although the furnace in which the experiments were tried was defective, it was found that, in consequence of crucibles being dispensed with, and less fuel being required, a considerable economy was effected.

DIAMONDS USED FOR BORING HARD ROCKS.—An instrument for this purpose is now being employed in France, made out of a tube furnished with a circular cutter of rough diamonds. It is caused to revolve, and as it enters into the stone, the cutter scoops out a cylinder, which is afterwards easily taken out of the tube. Holes in hard granite for blasting purposes, 47 millimetres in diameter, and from 1·10 metres to 1·20 metres deep, are thereby bored in one hour. This would require two days' work in the ordinary way. The diamonds, when examined through a magnifying glass, do not appear at all injured.

NEW GUN METAL.—The following is given by a correspondent of one of our contemporaries as the composition and mode of forming the new alloy which has been proposed in Austria as a substitute for ordinary gun metal, consisting of copper and tin. It is composed of 90 parts of copper, from 34 to 44 of spelter, from 2 to 4 of iron, and from 1 to 2 parts of tin. The iron, which must be wrought-iron, is put at the bottom of a crucible with the copper upon it, and the whole exposed to a very high temperature. The tin is then added, and afterwards the spelter. The metal is stirred, left for a minute or two, stirred again, and afterwards cast. A 12-pounder gun made of this alloy, was heavily charged with powder, rammed full of sand, plugged at the muzzle with a piece of iron, and in this state fired. All the gas resulting from the ignition of the powder escaped through the touch-hole; and not only was the gun found to be uninjured, but on careful examination not the smallest alteration in its internal diameter could be detected.

CONSOLIDATING CAST-STEEL.—Mr. J. M. Rowan, of Glasgow, proposes to consolidate cast-steel, or metal produced by the pneumatic process, by compressing it whilst still liquid or nearly so, whereby it is rendered much better adapted for subsequent processes.

ALUMINIUM BRONZE.—We had occasion in our last issue, when speaking of aluminium to refer to the various articles manufactured in this metal by Messrs. Reid and Sons, of Newcastle. This firm also use a metal designated aluminium bronze, and which may contain different per centages of aluminium. It being found that a very small proportion of aluminium, added to copper, produces a compound metal of great hardness, one specimen we have seen containing 90 per cent. copper, and 10 per cent. aluminium, was so hard that the file hardly makes any impression, whatever, on it. Indeed, it would appear that there should be no difficulty in manufacturing engineering machinery and tools of this metal. A pair of scissors manufactured in this compound metal have, we understand, been found, to cut quite as well as scissors made of steel.

APPLIED CHEMISTRY.

ON CHLOROFORMIC SOLUTION OF GUTTA PERCHA, BY WILLIAM HODGSON, JR.—Take of gutta percha, in small slices, an ounce and a-half; chloroform, twelve fluid ounces; carbonate of lead, in fine powder, two ounces. To eight fluid ounces of the chloroform contained in a bottle, add the gutta percha, and shake occassionally till it is dissolved, then add the carbonate of lead, previously mixed smoothly with the remainder of the chloroform, and, having shaken the whole thoroughly together several times, at intervals of half-an-hour, set the mixture aside, and let it stand for ten days, or until the insoluble matter has subsided, and the solution has become limpid, and either colourless or of a slight straw colour. Lastly, decant, and keep the solution in a glass stopped bottle.

THALLIUM.—On this new metal the Academy of Sciences has received a second communication from M. Lamy, from which it appears that if the discoverer, Mr. Crooks, at first discovered it to be a non-metallic substance he was not far wrong. At least, M. Lamy finds it wanting in one of the chief properties of metals, viz., the power of conducting electricity and heat, since the effects of induction developed in the metal are of but slight intensity when the circuit of the pole is successively closed and broken. Thallium and its compounds are diamagnetic; its density is enormous, being 11·862, or 0·5 more than lead; its specific heat is 0·0325; its chemical equivalent, 204. The aqueous solutions of its salts are not precipated either by alkalies or alkaline carbonates, or by the yellow and red ferrocyanides of potash. But hydrochloric acid produces on all but insoluble white precipitate, which is a protochloride; iodide of potassium, chloride of platinum, and chromate of potash yield yellow and insoluble precipitates. Zinc precipitates thallium from its solutions, especially from that of the sulphate, in brilliant laminæ variously ramified. Thallium combines with oxygen in two different proportions. The protoxide is soluble in water, to which it imparts alkaline and caustic properties. It is yellow if hydrated, and black in the contrary case; if heated in concentrated alcohol, a part of it is dissolved, and a curious compound produced, called thallic alcohol by M. Lamy. It is a limpid oil, containing great refractive power and a caustic taste. Its density is 3·50. The black peroxide is obtained by burning thallium in oxygen; it is composed of one equivalent of metal and three of oxygen. It is insoluble and melts at a bright red heat, losing some of its oxygen. The carbonate of thallium is soluble in water, and crystallizes in long prismatic needles of a greyish yellow. The nitrate is the most soluble salt of this metal. There are three chlorides and one sesqui-chloride, crystallizing in fine yellow hexagonal plates. Its density is 5·90.

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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 NOVEMBER 21st, 1862.

3125 W. Sinnock—Treatment and combination of fibrous materials.
3126 C. Hadfield & W. A. Atkins—Dressing bricks and tiles.
3127 J. Townsend—Damping and preserving vegetable substances and other textile materials and fabrics.
3128 J. R. Napier & W. J. M. Rankine—Boilers, and valvular mechanism for steam engines.
3129 W. E. Gedge—Elastic fastenings for gloves.
3130 D. Saul—Crinoline skirts.
3131 J. Stuart—Extracting the fibre from zostera marina and other aquatic vegetable productions.
3132 T. Walker—Utilizing sewage matter.
3133 C. Wagner—Strengthening, securing, and rendering more durable the soles of boots and shoes.
3134 E. W. Swinburne—Soda
3135 G. G. Sanderson—Armour for fortifications and floating and other batteries.
3136 J. Taylor, jun.—Tiles or moulded blocks for building purposes.
3137 C. A. Orth—Apparatus for obtaining and applying motive power.
3138 S. & C. Deacon—Tops, caps, and windguards for chimnies
3139 A. Sutton—Time indicator for public vehicles and other uses.

DATED NOVEMBER 22nd, 1862.

3140 W. E. Gedge—Elliptical compass.
3141 W. E. Nethersole & C. Buckland—Safety signals for fire-arm practice.
3142 M. Mishores—Handles for umbrella, parasol, or other like sticks from soft canes.
3143 C. de Bergue—Metal reeds for weaving.
3144 C. Powell—Watches.
3145 W. Clark—Candle lamps
3146 A. V. Newton—Cutting corks.
3147 J. Webster—Burners and blow pipes.

DATED NOVEMBER 24th, 1862.

3148 T. J. Searle—Raising and forcing water.
3149 J. B. Howell—Armour and other plates, and shot and shell.
3150 W. Clark—Obtaining a vacuum or partial vacuum, as applied in the manufacture of paper.
3151 R. & W. Hawthorn—Pump valves
3152 J. Barclay—Rollers to be used in machinery for printing textile materials and fabrics, and drying and finishing the same.
3153 J. H. Johnson—Burnishing metal surfaces.
3154 E. Leigh—Cotton gins.
3155 W Tatham—Preparing and spinning cotton, wool, flax, and other fibrous materials
3156 N. J. Amies—Fabric to be employed as a substitute for elastic woven or braided webs.

DATED NOVEMBER 25th, 1862.

3157 J. Moule—Deodorising mineral oils and hydrocarbons.
3158 T & L. Robertshaw—Textile fabrics.
3159 A. L. Woolf—Metallic alloy.
3160 E. Wadsworth—braid
3161 J. S. Jarvis & J. H. Brierley—Leather collars.
3162 W. B. Caulfield—Porous stems for tobacco pipes.
3163 G. Henderson—Steam engines.
3164 G. Ransom—Preparing clay for brick making and other purposes.
3165 A. V. Newton—Sewing machines.
3166 W. Longley—Making bricks.
3167 T. M. Elton—Soap

DATED NOVEMBER 26th, 1862.

3168 T. Fletcher—Rollers, cans, moods, and bobbins.
3169 J. Aspell & E. Booth—Looms for weaving.
3170 J. Steinthal—Mourners' blacking.
3171 F. Palling—Fountain penholder.
3172 J. F. Fovenaux—Pulverising or dividing liquids into spray.
3173 W. Austin—Cartridge cases.
3174 J. R. Danks & B. P. & R. P. Walker—Boot and shoe heel and toe tips and clog irons.
3175 A. V. Newton—Preparing oxide of zinc as a pigment.

DATED NOVEMBER 27th, 1862.

3176 J. Halford—Treatment of a mineral substance to be used in the manufacture of iron and steel in the processes of casting and moulding metals, and the manufacture of paint.
3177 A. A. Théloux & P. A. Paumier—Atmospheric sailing propeller.
3178 F. W. Hartley—Obtaining certain products resulting from the manufacture and purification of coal gas.
3179 T. Keyworth—Motive power machinery.
3180 W. T. Rowlett—Knit or looped fabrics.
3181 D. & D. Auld—Working furnaces and steam boilers.
3182 J. L. Linton—Generating steam.
3183 D. Veerkamp & C. F. A. Van Trigt—Treatment of old manufactured fabrics, in order to obtain useful fibrous products therefrom.
3184 W. Clarke—Preservation of animal and vegetable substances.
3185 W. Clark—Gas burners.

DATED NOVEMBER 28th, 1862.

3186 J. Carbonell—Preparing, manufacturing, and washing the paper pulp derived from the esparto plant
3187 W. A. Waddington—Cutting wood.
3188 J. T. Caird—Steam engines.
3189 J. H. Johnson—Indicating the pressure of electric conductors in foreign bodies.
3190 F. Boecke—Sewing fabrics.
3191 J. Cresswell & E. J. Greves—Hearses and funeral carriages.
3192 S. J. Browning—Brewing
3193 W. Clark—Permanent way of railways.
3194 W. Buller & J. H. Mugford—Spur supporting rings for fixing plates, dishes, and other articles in glost ovens.
3195 J. F. Delany & J. C. R. Okes—Double cylinder expansive steam engines.
3196 J. Adams & W. C. White—Apparatus for boiling and evaporating.
3197 A. Dudgeon—Packing for steam and other engines and machinery.

DATED NOVEMBER 29th, 1862.

3198 W. R. Gedge—Clocks
3199 T. Blackburn & M. Knowles—Looms for weaving.
3200 F. G. Taylor—Washing machines
3201 J. Crompton—Ploughing, harrowing, clearing, and drilling land.
3202 T. Lloyd—Wheels of vehicles.
3203 T. Evans—Antigraphilos.
3204 W. Clark—Cutting corks and other stoppers.
3205 F. Vreber—Ornamenting playing cards.
3206 J. C. Robertson & W. C. White—Tap or cock.
3207 Rev. H. Moule—Locomotive engines, and apparatus for generating steam for steam engines.
3208 D. Sutton—Washing linen and other fabrics and garments.
3209 J. Anderson, C.E.—Tyres of railway wheels, rails, switches, and crossings of railways.
3210 R. K. Penson—Warming railway carriages.
3211 M. Henry—Leather.

DATED DECEMBER 1st, 1862.

3212 H. L. Emery—Threshing machines.
3213 P. Bourne—Miners' lamps.
3214 G. F. Griffin—Permanent way of railways.
3215 T. Waller—Stoves.
3216 J. Irwin—Cultivating land
3217 R. Flude—Looms for weaving narrow fabrics.
3218 J. Coppard—Appliances for horse shoes, to produce the effect of what is termed roughing.
3219 J. Romer—Bullion and metallic flue drawn wire.
3220 W. Clark—Apparatus applicable as a pump, water meter, hydraulic motor, or a steam engine.

DATED DECEMBER 2nd, 1862.

3221 P. W. Renter—New compound for dyeing and printing purposes
3222 R. D. Johnson—Pocket watches.
3223 B. Oldfield—Looms.
3224 A. V. Newton—Steam and other vessels.
3225 H. Twelvetrees—Cleaning knives, forks, and boots.
3226 H. Twelvetrees—Sawing, filing, mortising, and turning apparatus.
3227 H. Twelvetrees—Washing, wringing, and mangling machines.
3228 P. Brassert—Apparatus for saving life and property in cases of fire and burglary.
3229 J. & J. Craven & J. Robinson—Looms for weaving.
3230 G. F. Blumberg—Producing designs in or on glass.
3231 J. Wheatley—Construction of ships of war and the manufacture of armour plates for ships, forts, and batteries.
3232 T. Cook—Envelope folding machinery.
3233 G. T. Bousfield—Permanent ways of railways.
3234 G. T. Bousfield—Apparatus for discharging guns or ordnance.
3235 D. Graham—Steering and manœuvring ships or vessels
3236 A. P. Charles—Candles and night lights, and lamps for burning the same.
3237 R. K. Cantley—Nitro thermal baths.
3238 H. J. Simlick—Cigar and pipe lights.
3239 B. Browne—Knobs or handles or door locks, and the mode of connecting same with the sliding bolts thereof for advancing and drawing back said bolts.

DATED DECEMBER 3rd, 1862.

3240 H. Wilde—Electro magnetic telegraphs
3241 A. T. Becks—Cutting sheets of metal.
3242 R. B. Thomas—Apparatus for turning over the leaves of music.
3243 C. F. Claus—Carboy hampers
3244 A. Morton—Lawn mowing machines.
3245 W. H. Browne—Gas stoves.
3246 I. I. Abadie—Imitation lace and guipure veils.
3247 A. F. Eden—Taking minute photographic pictures and magnified pictures of microscopic objects.

DATED DECEMBER 4th, 1862.

3248 C. H. Roeckner—Coffer dams for enclosing or keeping back the flow of water and preventing inundations, and apparatus for lowering or raising weights.
3249 H. Swan—Stereoscopic apparatus.
3250 J. Grant—Turntables for portable railways.
3251 R. D. Kay—Finishing of endless machine blankets for printing purposes.
3252 J. Braddock—Apparatus for effecting the separation of impurities from the water employed in steam boilers, and for effecting the circulation of the said water.
3253 F. D. Delf & T. C. Gibson—Apparatus whereby petroleum and other oils and hydro carbons can be safely carried and stored.
3254 G. Lewal—Hot air apparatus in cast iron or any other metal or substance consisting of prismatic tubes, to be applied to chimnies with flues and heat conduits.
3255 H. Castelbon—Press to be used in the manufacture of tiles and bricks.
3256 J. Robinson—Ships and vessels.
3257 J. Biggs, J. Johnson, T. Richardson, and T. Arnold—Warp fabrics.
3258 R. Wallis—Loading and unloading vessels and transporting sacks, casks, and other packages from one landing place to another.
3259 R. Hornsby, jun.—Cutting and pulping turnips and other vegetables.
3260 T. G. Webb—Articles of pressed glass.

DATED DECEMBER 5th, 1862.

3261 M. Tildesley & E. Sharpe—Earthenware knobs.
3262 L. Christoph, W. Hawksworth and G. P. Harding—Drilling, drawing, and rolling metals.
3263 E. B. Wilson—Railway wheels.
3264 T. E. Blackwell—Barometers or instruments for measuring altitudes or the pressure of the atmosphere or elastic fluids.
3265 J. M. Rigby—Pressing cotton or other fibrous materials.
3266 P. Cowan—Purifying gas.
3267 W. J. Smith—Collars, cuffs, and wristbands.
3268 R. Walton—Wearing apparel for the neck.
3269 C. Galleti & F. Stefano—Furniture.

DATED DECEMBER 6th, 1862.

3270 H. A. Bonneville—Fabrication of stockings and socks.
3271 R. Thorp—Covering for steam boilers and other surfaces to prevent the radiation of heat.
3272 J. & M. Craig—Apparatus for the manufacture of clay.
3273 G. Wright—Food for cattle.
3274 W. McNaught—Washing and drying textile fabrics and materials.
3275 J. Campbell—Hackling flax and other fibres.
3276 J. Burchall & E. Borrows—Propellers for ships and other navigable vessels.
3277 E. & W. Ullmer—Cylinder printing machines.
3278 R. McClintock—Carriage axles.
3279 R. E. Donovan—Apparatus for the prevention of railway accidents.
3280 J. Joce—Compositions for producing artificial sea water.
3281 W. Palliser—Screw bolts.

DATED DECEMBER 8th, 1862.

3282 G. Lowry—Hackling flax, and preparing to be spun flax, hemp, and tow.
3283 J. L. Budden—Obtaining and applying motive power for propelling or other purposes.
3284 J. Sellars—Pulp or half stuff used in the manufacture of paper and pasteboard.
3285 P. Todd—Pickers used in looms for weaving.
3286 R. A. Brooman—Kneading machines.
3287 G. A. Hudsart—Buttons.
3288 C. Sanderson—Bands for driving machinery and lifting weights.
3289 W. E. Newton—Preserving animal substances.
3290 J. Hillier—Hinges and joints.
3291 J. Hilliar—Ventilating, and the exclusion of dust or draught, insects, or other animals from apartments, carriages, or other confined spaces.
3292 E. T. Hughes—Electro-galvanic apparatus.
3293 J. A. & C. L. Kissling—Renewing worn out files and rasps.
3294 J. H. Johnson—Steam generators.

DATED DECEMBER 9th, 1862.

3295 T. Wingate, jun.—Dredging machinery.
3296 V. Miriand—Manufacturing paste with the dried pulp of rhubarb to be used as preserve.
3297 M. F. Bergeron—Gunpowder.
3298 W. Clark—Photographic apparatus.
3299 R. A. Brooman—Treating liquorice root to obtain liquid and solid extracts therefrom.
3300 G. Jeffries—Breech-loading fire arms.
3301 J. Howard, J. Bullough, & T. Clegg—Preparing cotton to be spun.
3302 J. M. & E. D. Syers—Deodorising petroleum, shale, and other oils.
3303 P. Effertz—Making bricks, tiles, and drain pipes.
3304 W. E. Newton—Fire arms.
3305 E. B. Wilson—Rolling metals.

DATED DECEMBER 10th, 1862.

3306 J. Lamb—Tissue paper for transferring patterns and designs.
3307 W. Inglis—Steam boilers.
3308 L. A. Lange—Making and moulding fruit jellies and preserves.
3309 J. K. C. Taunton—Ornamentation of metallic bedsteads.
3310 S. B. Whitfield—Dovetail joints used in metallic bedsteads
3311 M. Osborne—Cast iron fenders.
3312 A. P. Price—Colours.
3313 H. Chalmers—Textile materials.
3314 W. A. Turner—Cutting or paring starch.
3315 W. Clark—Umbrellas.
3316 J. King—Signalling on railways.
3317 E. Toubee—Extracting oils and fatty matters from shoddy or refuse wool, skins, or skin pieces, glue pieces, cotton waste, and other animal or vegetable matter, and producing an artificial manure.

DATED DECEMBER 11th, 1862.

3318 I. Speight—Horse hoes.
3319 W. Tinstram & H. Brereton—Sizing yarns and threads.
3320 J. R. Brecon & T. Douglas—Fire bricks.
3321 R. A. Rouald—Printing textile and felted fabrics.
3322 R. Clark—Machinery for boring, winding, and lifting for mining purposes.
3323 A. W. Burgess—Preparation of anchovies.
3324 J. Imray—Mixing and kneading apparatus
3325 W. Gooding—Ploughs.
3326 T. E. Vickers—Ordnance.

DATED DECEMBER 12, 1862.

3327 G. Winniarter—Portable houses, walls, or partitions of buildings, strong rooms, safes, refrigeratories, reservoirs, piers, and other structures.
3328 H. Sanderson—Knives and forks.
3329 J. E. Roussel—Hand and power looms.
3330 J. Gaskell & H. Walmsley—Regulating the tension of yarn in warping, winding, sizing, and weaving.
3331 C. Hancock & S. W. Silver—Compounds and substances applicable for electric insulation.
3332 A. Mills—Reefing and unreefing sails of ships.
3333 G. Clark—Fortification for the defence of ships, batteries, and forts.
3334 S. Fox—Gas retorts.

DATED DECEMBER 13th, 1862.

3335 J. Brown—Armour plates.
3336 J. W. Baker—Spinning cotton.
3337 J. Brown—Hydraulic machinery.
3338 E. Thorold—Drill braces.
3339 C. Corbet—Rails for railways.
3340 R. Aitken—Locomotive engines.
3341 J. Petrie—Washing wool.
3342 J. J. Thompson—Making pies.
3343 W. E. Newton—Repairing the rails, points, and switches of the permanent way of railways.
3344 M. Henry—Fitting propellers to ships.

DATED DECEMBER 15th, 1862.

3345 M. J. Roberts—Preparing and spinning cotton.
3346 W. Beatwick—Branding machines.
3347 R. Stanfield & J. Dodgeon—Looms for weaving.
3348 G. Buchanan—Crushing sugar canes.
3349 W. Phelps—Locks.
3350 M. Hyams—Cigars
3351 E. B. Wilson—Rolling metals.
3352 R. Kirk—Stopping railway carriages.

DATED DECEMBER 16th, 1862.

3353 J. McInnes & E. F. Prentiss—Distillation and treatment of petroleum
3354 J. Farley & J. Crowther—Steam engines.
3355 C. C. Wardle—Ornamenting textile fabrics.
3356 J. S. and S. Hancock—Anti-garotte knives.
3357 O. Dickin—Table fork.
3358 J. J. Lemon—Book trays.
3359 W. and A. Smedley—Warp lace machines.
3360 W. Hudson, H. Moore, C. Catlow, and S. Newbury—Looms for weaving.
3361 J. L. W. Thudichum—Collecting human excreta.
3362 3362 G. C. Wallich—Deep sea sounding.
3363 R. Schomburg and A. Baldamus—Oils
3364 H. Jorns—Clocks.

DATED DECEMBER 17th, 1862.

3365 R. Hattersley—Classing printers' types for composing machines.
3366 W. Teague—Preparing fibrous materials.
3367 A. Albini—Fire-arms.
3368 C. Defries—Lamps.
3369 T. Knowles—Preparing and spinning cotton.
3370 J. R. Hampson—Packing bales.
3371 J. Thorne—Regulating the flow of gas.
3372 J. Ramsbottom and G. Hacking—Measuring and registering the flow of water.
3373 J. W. Hawden—Spinning cotton.
3374 T. C. Barraclough—Tobacco.
3375 F. De Wylde—Preservation of lead surfaces.
3376 D. Latter—Ploughs.
3377 R. Wheeler—Ploughs.
3378 H. Burton—Castors.
3379 G. A. Huddart—Buttons
3380 W. Clark—Holders for lamps
3381 C. J. L. Leffler—Armour for ships

DATED DECEMBER 18th, 1862.

3382 E. Precht and V. Tuepken—Matches
3383 E. Lepanteur—Salt for dyeing textile materials
3384 J. Clayton—Reverberatory furnaces
3385 E. Haberland E. Suckow—Spinning cotton
3386 G. Russell—Cranes
3387 W. V. Wilson and F. A. Manning—Colouring matters
3388 J. and A. Brierley—Carding engines
3389 J. Pernod—Purpurine
3390 J. Savory—Powders for diseases of the throat
3391 J. Longland—Street lamps
3392 S. C. Lister—Spinning flax and silk
3393 A. V. Newton—Transmuting power
3394 J. Hodge—Preparing and combing wool
3395 J. Holden—Washing wool
3396 J. L. W. Thudichum—Preservation of beer

DATED DECEMBER 19th, 1862.

3397 W. S. Longridge—Rolling tyres and hoops
3398 E. B. Wilson—Forging and pressing metals
3399 D. Davidson—Telescopes
3400 A. V. Newton—Attaching metal eyelets to cloth
3401 J. Dalton—Knitting machinery

DATED DECEMBER 20th, 1862.

3402 J. B. Morrison—Washing machines
3403 F. W. Harvey—Connecting rudders to ships
3404 A. T. Blakely—Breech loading ordnance
3405 J. Nettleton—Stoves
3406 J. McCausland and J. Rubino—Locks for purses
3407 J. Cowper—Turning up rags
3408 A. V. Newton—Automatic toy figures
3409 J. Platt and W. Richardson—Scutchers of cotton
3410 W. Perkin—Substitute for turpentine

DATED DECEMBER 22nd, 1862.

3411 F. C. Bakewell—Transmitting and receiving communications by means of electricity
3412 J. Mclean—Obtaining oil from shale
3413 W. Francis—Cutting soap
3414 A. S. Stocker—Rolling iron
3415 G. E. M. Gerard—Fabrication of threads from vulcanized india rubber
3416 E. R. Dann—Goffering apparatus
3417 R. A. Brooman—Stoves
3418 M. Clark—Treating waste liquors obtained when dyeing turkey red colours
3419 J. H. Dalhoff—Cutting files
3420 C. Farrar—Treating certain fibrous materials

DATED DECEMBER 23rd, 1862.

3421 C. Pieper—Governor for steam engines
3422 F. Parker—Carriages
3423 R. A. Brooman—Colouring matter
3424 C. A. F. Collette—Lac
3425 J. Patterson—Grinding, crushing, cutting, cleaning, and shelling farm or vegetable produce
3426 E. B. Wilson—Malleable iron and steel
3427 G. Haseltine—Converting petroleum or coal oil into gas
3428 J. Whitley and J. W. Burton—Permanent way of railways
3429 S. Russell—Stereoscopes

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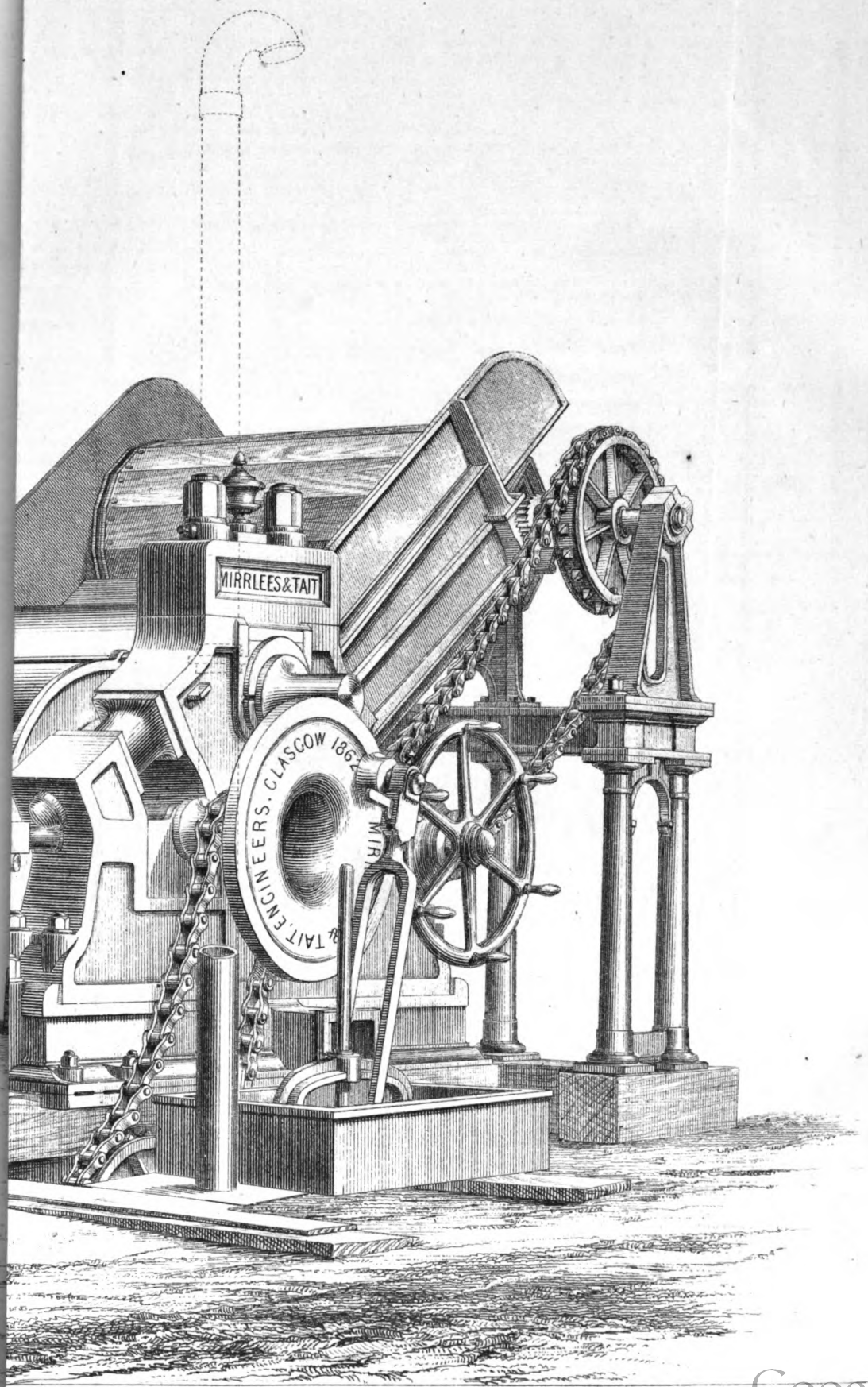

W. Smith, C.E. direx

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LIST

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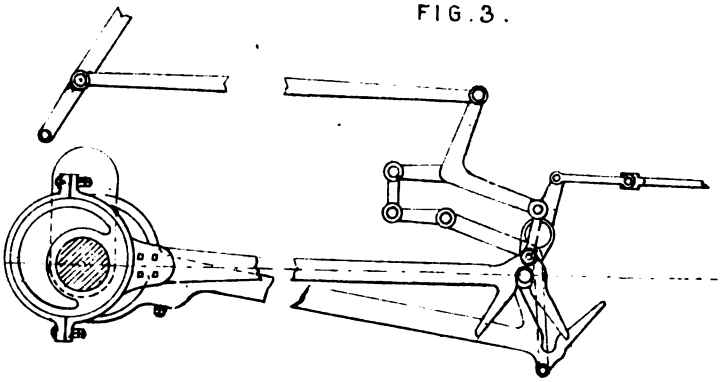
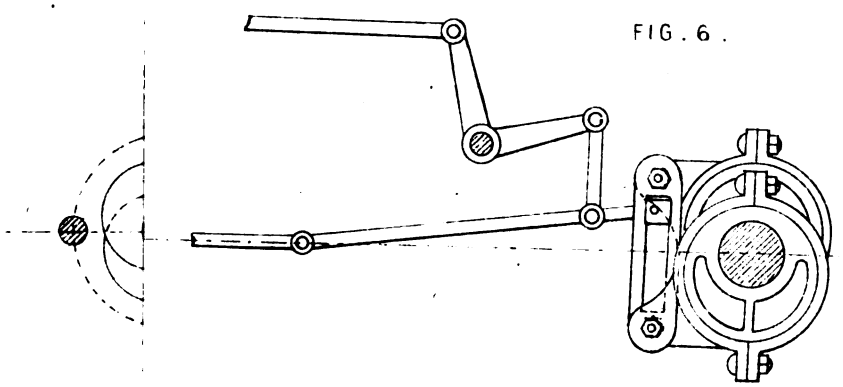
FIG. 3.



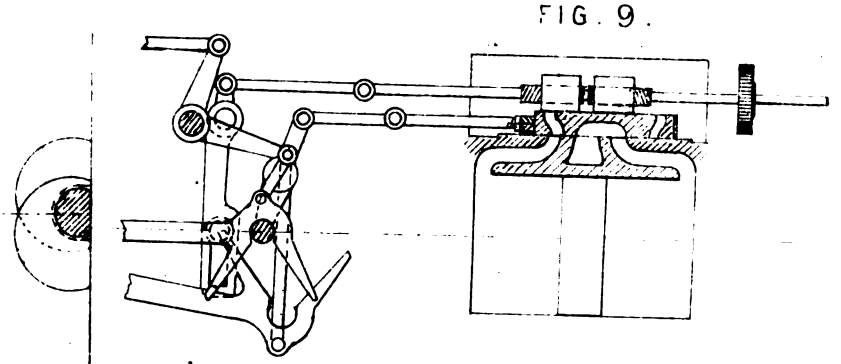
SHARP & ROBERTS' VALVE-GEAR – 1840.

FIG. 6.



WILLIAMS' EXPANSION-GEAR.

FIG. 9.



MEYER'S EXPANSION-GEAR – 1842.

W. SMITH, C.E. del.

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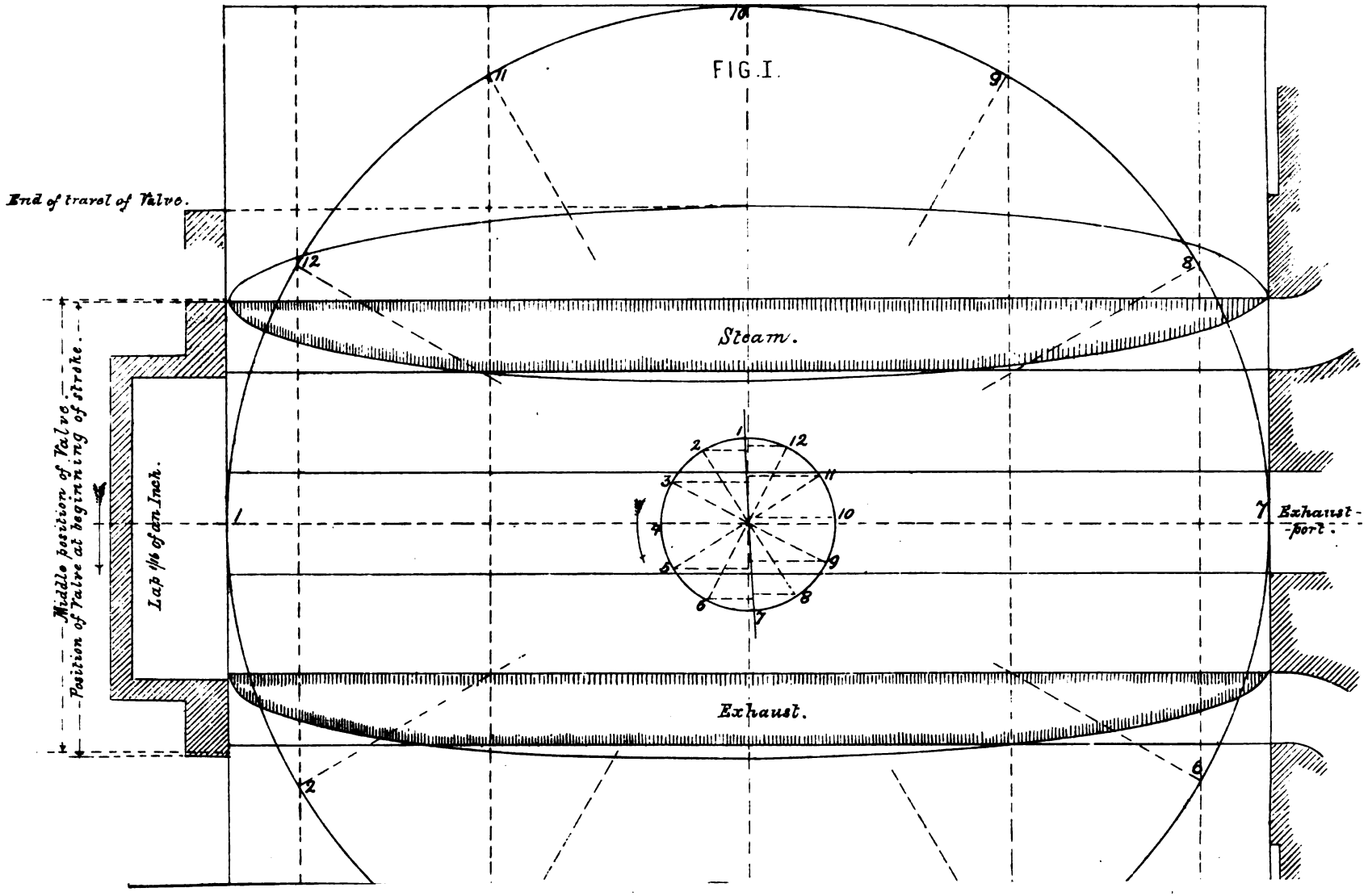
GENERAL DIAGRAM OF MOTION OF OLD VALVE.



GENERAL DIAGRAM OF MOTION OF NEW VALVE.

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THE ARTIZAN.

No. 2.—Vol. 1.—Third Series.

FEBRUARY 1st, 1863.

SUGAR MILL AND STEAM ENGINE.

By Messrs. Mirrlees and Tait, Glasgow.

(*Illustrated by Plate* 230.)

Our copper-plate engraving represents a perspective view of a sugar mill and steam engine complete, manufactured by Messrs. Mirrlees and Tait, of Glasgow, who have earned a wide-spread reputation for the excellence of the machinery manufactered by them for the extraction of the juice from the sugar cane.

The subject represented by our plate formed a very prominent object amongst the machinery in motion in the late International Exhibition, where, doubtless, numerous of our readers have seen the apparatus at work. We have also included a notice of the machinery exhibited by Messrs. Mirrlees and Tait, in Number 6 of the series of Artizan International Exhibition supplementary numbers, and in which we also gave woodcut illustrations of the sugar mill only.

The mill has three crushing rollers of cast iron, each 33 in. diameter, and 7 ft. long, the upper one of which drives the two side ones by strong pinions keyed on the ends of their respective shafts or gudgeons. This upper roller revolves in a line with the axis of the largest of the train of heavy spur wheel gearing for transmitting the power of the engine to the mill, and is connected to it by a short malleable iron shaft, with two large loose fitting couplings, which allow it to be easily disconnected. It is secured from rising by strong cast iron covers and four wrought iron bolts, which pass downwards through the headstocks, mill bed, and the heavy timbers on which the mill sits, beneath which they are secured by wrought iron washers and cottars.

Each side roller can be adjusted separately to the requirements of its work by large set screws, bearing on thick malleable iron plates fitted to the backs of the journal bushes.

The headstocks, which carry the bearings of all the rollers, are necessarily very strong, having to resist the entire force of the engine acting through a leverage of 16 to 1. They are so made that each roller can be taken out or replaced without interfering with the other parts.

The velocity of the surface of the rollers is about 18 ft. per minute, and the weight of each, with its malleable iron shaft or gudgeon, about 10 tons.

The mill bed upon which the headstocks are solidly fixed is a casting in one piece, which serves also to receive the cane juice as it falls from the rollers. The juice is delivered by a spout at one side of the bed-plate into a separate cast iron cistern provided with perforated copper strainers.

In this cistern—for the purpose of elevating the cane juice into the proper receiver—is placed a very large pump lined with brass, with a brass bucket worked slowly from a crank disc on the end of one of the roller gudgeons.

The sugar canes are distributed on an endless travelling table or cane-carrier, also driven from the end of one of the roller gudgeons by a friction clutch and pitch chain gear. The movement of the cane-carrier brings the canes to the mill, and projects them over a steep inclined feeding-table into the bite of the upper and first roller. Passing through these, the canes are deflected upwards by the concave upper surface of an iron beam, fixed between the rollers into the bite of the upper and the other side roller, where the utmost amount of juice is extracted, and the refuse cane or megass is delivered out to another endless table, which carries it away to be dried in the sun or stored for fuel.

The product of this mill in cane juice is estimated at 4000 gallons per hour, equal to about 2 tons of dry sugar.

A prize medal was awarded by the Jury of Class 8 to Messrs. Mirrlees and Tait for the general excellence, good design, and good workmanship of the machinery we have just described.

The mill is worked by a high pressure beam steam engine, constructed upon a very deep massive bed-plate, cast in one piece. Into this the columns are fitted the entire depth of the bed, and the whole is bound together by strong malleable iron bolts, cottared into the bed-plate below, passing through the centre of the columns, and secured above the entablature by large nuts.

The steam cylinder is 22in. in diameter, having a stroke of 4ft. 6in. Besides the ordinary slide valve there is a gridiron expansion valve, worked by an eccentric on the crank shaft, and by means of a slotted link the amount of expansion can be varied with the utmost facility while the machinery is at work.

The power of the engine is transmitted to the mill, and the speed reduced in the proper ratio, by a double train of very heavy spur wheels, the axes of which are rigidly secured to a deep cast iron bed-plate of similar design to the engine bed. The largest wheel of this train is expressly designed for the specialities of the work to be performed. The centre, arms, and segments are all made in separate pieces. The arms are of circular section and hollow, thus securing the best distribution of the metal for all strains, the whole fitted with great accuracy and secured by turned bolts.

A CRITICAL AND HISTORICAL REVIEW OF LOCOMOTIVE ENGINEERING.

By J. J. Birckel.

(*Continued from page* 8.)

(*Illustrated by Plates* 231 *and* 232.)

To proceed in the manner sketched out at the outset of our subject, we have now to lay before our readers, and to inquire into the various questions relating to the steam engine proper, under which name is to be comprized the cylinder, the steam distributing apparatus, and those parts of machinery by means of which motion is finally communicated to the engine.

In treating of the boiler, we have seen already that by adopting Pambour's method of determination of the heating surface, the diameter of the cylinder, the stroke and the diameter of the driving wheel are conspicuous elements in the formula which defines the amount of that heating surface. We reproduce it here for the facility of reference,

$$A = v \cdot \frac{34{,}318}{c \cdot u} \cdot \frac{d^2 l}{D} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where all the symbols keep their former meaning, but where c stands for the co-efficient of efficiency of steam for the particular grade of expansion at which it is intended to work the engine when it performs its maximum duty at the speed v.

This formula teaches us that the heating surface required to perform a certain duty, is directly proportional to the product of the square of the diameter of the cylinder, by the stroke, and inversely as the diameter of the driving wheel; and as the diameter of the cylinder (which is in the main regulated by the total resistance to be overcome), may be made to vary by altering the ratio of stroke to diameter of driving wheel, it is necessary to inquire which are the best proportions to be adopted for these several elements of the engine. It will be at once perceived, however, that for a given resistance at the circumference of the driving wheel the factor $\frac{d^2 l}{D}$ must remain constant, for if the ratio $\frac{l}{D}$ be made to vary,

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d^2 will vary at the same time in an equal but inverse ratio; the relative values, d, l and D, therefore, cannot in any way affect the value A of the heating surface, and must be decided upon from considerations having reference to the efficient working of the engine alone. In treating of this question, Mr. Clark says, "It is desirable to limit the diameter of piston, and consequently the area, in order to prevent an excessive concentration of pressure on the bearings of the driving wheel; it is desirable also to limit the speed of piston in order to moderate the number and violence of the reciprocations," to which we would also add, *in order to reduce as much as possible the bad effects of wire drawing.* In his chapter treating of the data regulating the general proportions of the engine, Mr. Clark says that the maximum speed of piston should be 600ft., or 15ft. per minute for every mile of speed per hour; that the orthodox ratio of diameter of cylinder to stroke is as 3 to 4, and that the ratio of stroke to diameter of driving wheel should be from $1 + 3\frac{1}{2}$ to $1 + 4$, for engines of high speed, and should not in any case exceed $1 + 2$.

In order to test the correctness of these statements, we must refer to results obtained from actual practice, which, at the present day, should be the best source of information upon all questions governed chiefly by practical, rather than by theoretical considerations, and subjoined is a short table of proportions of engines from the recent practice of Messrs. Sharp, Stewart, and Co., Fairbairn, Ramsbottom, and others.

TABLE A.

Designation of Engines and Makers.	Diameter of Cylinder.	Stroke.	Diameter of driving wheel.	$\frac{d}{l}$	$\frac{l}{D}$	$\frac{d^2 l}{D}$
Express and Passengers.	in.	in.	ft. in.			
Sharp, Stewart, and Co.'s, London, Chathan, and Dover.	17	22	6 6	3 ÷ 3·88	1 ÷ 3·54	0·565
Sharp, Stewart, and Co.'s, Great Western	16	24	7 0	3 ÷ 4·5	1 ÷ 3·5	0·508
Sharp, Stewart, and Co.'s, London and North Western..	16	22	7 0	3 ÷ 4·12	1 ÷ 3·82	0·465
Sharp, Stewart, and Co.'s, Lucca and Pistoja.....	15	20	5 6	3 ÷ 4	1 ÷ 3·3	0·473
Ramsbottom's Lady of the Lake.....	16	24	7 6	3 ÷ 4·5	1 ÷ 3·75	0·474
Ramsbottom's Crewe common passenger	16	20	7 0	3 ÷ 3·75	1 ÷ 4·2	0·423
Fairbairn's Wolverton passenger	16	21	6 0	3 ÷ 3·93	1 ÷ 3·48	0·518
			Mean...	3 ÷ 4·1	1 ÷ 3·72	0·490
Goods' Engines.						
Sharp, Stewart, and Co.'s. London, Chatham, and Dover	17	24	5 0	3 ÷ 4·23	1 ÷ 2·5	0·802
Sharp, Stewart, and Co.'s, Dublin and Wicklow	16	24	5 0	3 ÷ 4·5	1 ÷ 2·5	0·711
Ramsbottom's, Crewe.....	17	24	5 0	3 ÷ 4·23	1 ÷ 2·5	0·802
McConnell's, Wolverton.....	16	24	5 6	3 ÷ 4·5	1 ÷ 2·8	0·646
Fairbairn's, Wolverton	18	24	5 0	3 ÷ 4	1 ÷ 2·5	0·900
			Mean...	3 ÷ 4·29	1 ÷ 2·56	0·772

It appears from this table that for express or passenger engines, the ratio of diameter to stroke is about as 3 to 4, and for goods engines as 3 to $4\frac{1}{2}$ nearly, and as these ratios are regulated absolutely by the two general conditions, stability upon the rails, and available space between the rails, —no great departure from them is possible in practice, and on that account we feel inclined to qualify them as the only possible ratios, rather than the orthodox ratios; a similar remark may be made regarding the ratio of stroke to driving wheel, which, in the case of engines for quick traffic, is governed by the practical limit to speed upon the rails; and in the case of goods engines, by considerations of commercial economy, which we know are far from being absolute, as is evidenced by a comparison between the goods engines of this and of other countries, which shows that while here the diameter of driving wheels is from 5ft. 0in. to 5ft. 6in., in France and in America, it is more generally 4ft. 6in., and even less than that.

These ratios being decided upon, nothing would be easier than to define the diameter of the cylinder and the stroke for a given resistance at the circumference of the drivimg wheel, and for an assumed mean pressure in the cylinder: it being a universal practice now, to supply the engine with two cylinders, these dimensions will be obtained from the following general equation:—

$$144\, p_a \cdot \frac{\pi d^2}{4} \cdot 4\, l = R t\, \pi\, D$$

which for

$$l = \frac{4}{3} d$$

becomes

$$144\, p_a \cdot \frac{4}{3} d^3 = R t\, D$$

and

$$d = \sqrt[3]{\frac{3}{4} \cdot \frac{R t\, D}{144\, p_a}} \quad \ldots\ldots\ldots\ldots\ldots (9)$$

and for

$$l = \frac{4{\cdot}29}{3} d$$

$$d = \sqrt[3]{\frac{3}{4{\cdot}29} \cdot \frac{R t\, D}{144\, p_a}} \quad \ldots\ldots\ldots\ldots\ldots (10)$$

in which formula p_a expresses the mean actual pressure upon the square inch of piston, and the meaning of the other symbols remains as previously.

If for instance we would find the diameter of cylinder and stroke required to perform, the duty expressed by formula (1), of our previous paper in The Artizan of last month, in which case the total resistance, including back pressure at the circumference of the driving wheel, is 7561lbs.; taking p_a at 90lbs. and D = 8ft., we should have

$$d = \sqrt[3]{\frac{3}{4} \times \frac{7561 \times 8}{144 \times 90}} = 1{\cdot}5 \text{ ft.} = 18 \text{ in.}$$

which would give a stroke of 24 inches.

The method of course might be reversed, and, instead of assuming a certain mean pressure, we might assume the dimensions of the cylinder, and find the pressure required for these given data. We believe, however, that the former method is to be preferred, because in the present state of matters we are able to ascertain pretty accurately what mean actual pressure we have in the cylinder for a given maximum pressure in the boiler; and since we know that *high pressure* and *economy* are two correlative facts, by adopting the former method the engine may at once be made to work under the most economical circumstances possible, so far at any rate as pressure is concerned.

To define the mean actual pressure in the cylinder in terms of the pressure in the boiler, we shall not have recourse to Mr. Clark's formula for mean effective pressures, having found it to be incorrect in its results, and deficient of the element of loss of pressure sustained in the passage from the boiler to the cylinder; but we find the means of supplying our present

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want, partly from the valuable plate of indicator diagrams taken from the engine "Great Britain," on the Great Western Railway in 1847, '49, and '50; and partly from the chapter treating of the relative pressure in the cylinder, the valve chest, and the boiler. The former enables us to find the mean pressure in the cylinder for various grades of expansion as derived in each case, from seven or nine diagrams, taken at varying speeds of from 16 to 55 miles per hour; and the latter enables us to find the mean loss of pressure between the boiler and the cylinder, from observations made by Messrs. Gouin and Lechâtelier in France, and by Mr. Gooch, and also by Mr. Clark, in this country. These observations show in the first place, that the decrease of pressure diminishes in proportion as the opening of the steam regulator is enlarged, up to a certain point corresponding to an area of $\frac{1}{10}$th that of the piston, when a further increase of opening is not accompanied by a corresponding increase of pressure; the fact just stated is so self-evident that it deserves to be mentioned only on the ground of its leading to the knowledge of the maximum useful opening of the regulator; it is fully appreciated also by engine drivers generally, who work their engines as much perhaps from the regulator handle as from the expansion gear proper. But as we intend to deal with the condition of maximum power chiefly, those observations only will serve our present purpose which have been taken with a maximum useful opening of the regulator; we have to regret, however, that their number is exceedingly small. The most comprehensive of the several series recorded by Mr. Clark, are those made by Mr. Gooch, which indicate, simultaneously, the pressures in the cylinder, the valve chest and the boiler; and though we find it difficult to believe, as stated by Mr. Gooch, that the pressure in the steam chest, was actually greater than that in the boiler, yet do they seem tolerably trustworthy in the final result which we are inquiring into. The mean loss of pressure computed from thirty-six observations is by them shown to be 9 per cent. of the initial pressure in the boiler, and the maximum loss is 17 per cent. of the same, occurring at a speed of forty-three miles per hour and with an admission of 30 per cent. of the stroke. Mr. Clark's observations show a fall of pressure between the steam chest and the cylinder, varying from 9 per cent. to 20 per cent., and those of Messrs. Gouin and Lechâtelier show a loss of 16 per cent. between the cylinder and the boiler, and a loss of 12 per cent. between the cylinder and the valve chest at speeds of 29 miles per hour.

From these figures we think that we may safely infer that a loss of 23 per cent. of the pressure in the boiler is all that need be reckoned upon for engines working under ordinary circumstances, although when there is heavy priming, that loss may amount to 60 per cent.; with this assumption and with the plate of indicator diagrams, above referred to, we have computed the following table of mean actual pressures in the cylinder for various grades of expansion, expressed in percentage of the pressure in the boiler; in the same table we give the mean pressure in pounds per square inch, for a pressure of 150lbs. in the boiler, the mean actual pressure in percentage of the maximum pressure in the cylinder and the relative efficiency of steam for the corresponding grades of expansion.

Admission in per centage of Stroke.	Mean actual pressure in cylinder in per cent of pressure in boiler.	Mean actual pressure for maximum pressure of 150 lbs. in boiler.	Mean actual pressure in cylinder in per cent. of maximum pressure in cylinder.	Relative efficiency of steam.
		lbs. per sq. in.		
100	77	115·5	100	1·00
74	71·5	107·25	92·33	1·30
66	69·5	104·25	89·70	1·415
49	60·0	90·00	77·50	1·711
40	49·1	73·65	63·40	1·916
30	41·9	62·85	54·10	2·200

This table will enable the reader to apply the general formulæ (9) and (6), to any particular case which, in practice, he may be called upon to solve, he having but to remember that for goods engines the pressure and the relative efficiency, corresponding to the long periods of admission, are to be taken, and for express, or passenger engines, those corresponding to the short periods of, say, from 40 to 50 per cent.

Cylinders are made of cast-iron and should be of a hard quality of metal, in order to wear long without requiring to be bored out afresh; in earlier days they were made invariably of from $\frac{3}{4}$ to 1in. metal in the body, but of late it has become a frequent practice to make them $1\frac{1}{4}$in. thick, in order chiefly to get as much wear as possible without lining them up; they are made long enough to leave a clearance of from $\frac{3}{8}$ to $\frac{1}{2}$in. at each end between the covers and the piston when it has reached the end of its stroke, and are bell mouthed at the ends to admit of being rebored without renewing the covers which invariably project some distance into them. These latter are ground true upon the ends of the cylinders and are bolted to them by means of stud bolts varying from 8 to 16 in number and from $\frac{3}{4}$ to 1in. diameter.

Some attempts to introduce wrought iron cylinders have been made, chiefly with a view to avoid breakages in the body of the cylinder, but without success. Should steel, however, become so cheap, as it is now predicted it will become by the aid of Bessemer's process, we may look forward to the day when they will be made of cast steel.

When the diameter of the cylinder and the stroke are decided upon, the next point to settle is the area and the shape of the steam ports, and as it has been stated that the useful opening of the regulator amounts to one-twentieth the area of the piston, it is clear at once that, so far as the admission is concerned, the area of the ports should not be less than this amount; experience, however, teaches that the great condition of economy in the locomotive engine is an easy and quick release of the steam behind the piston, and one of the means of realising this condition is to provide ample area in the steam ports, which, on that account, is made of from one-twelfth to one-fourteenth that of the piston.

It does not appear, at first sight, that the shape of the steam port has any influence upon the easy, and we may say the economic flow of the steam; but when it is remembered that the fall of pressure between cylinder and valve chest may amount to 20 per cent. of the whole pressure, considering the short distance over which the steam has to travel here, as compared with the length of pipe between the regulator and the steam chest, it behoves us to inquire into the causes of this loss of pressure which entails such a material loss of mechanical effect, and to see whether it is not in some measure attributable to the shape of the steam ports.

Morin's experiments upon the flow of steam in stationary engines are calculated to enlighten us upon this subject, and show that the loss of pressure varies:—

1. As the square of the speed of piston.
2. As the square of the ratio of area of piston to area of steam passage.
3. As a factor dependent on bends and friction.
4. They show also that friction is proportional directly to the length of the passage and to its periphery; that is for passages of equal extent in length, and of equal area, that one will occasion the smallest loss by friction whose cross section has the smallest periphery: to illustrate our meaning let us suppose that a steam passage of 16ins. area is required; this may be obtained by

A circle $4\frac{1}{2}$in.	in diameter	having a periphery	of 14.1in.
A square 4in. × 4in.	„	„	of 16·0in.
A parallelogram 7in. × $2\frac{2}{7}$in.	„	„	of 18·6in.
A „ 11in. × $1\frac{5}{11}$in.	„	„	of 24·8in.
A „ 12in. × $1\frac{1}{3}$in.	„	„	of 26·7in.

which table shows that for a given area the circle has the smallest periphery, that it increases as we pass from the circle to the square, and from the square to the parallelogram, until in the last case, which is not an uncommon size of port, it is nearly double that of the circle. It is true that various conditions of the problem lead to the shape of a rather elongated parallelogram, yet is it good to call the reader's attention upon this fact, and to point out the propriety of reducing the ratio between the two sides of the port as much as possible, since wire drawing, which is the loss of *energy* of the steam occasioned by the work of friction against the sides of the port, will be much less with a wide port and a great travel of valve, than with a narrow but long port, and a small travel of valve.

We have now reached that stage of our study when we are called upon to detail before our readers and to describe the mechanical contrivances by means of which the steam is distributed into the cylinders, and as the problem of an advantageous and economic evolution of the mechanical work stored up in the steam is centered almost exclusively in these parts of the machinery, which might very properly be called the heart of the engine, we shall trace the history of their developement from the earliest time of locomotive engineering in order to give a full illustration of the amount of ingenuity and patient thought which has been spent upon the subject ere it was solved in a satisfactory manner.

One of the first conditions of existence of the engine is an easy and sure means of reversing its motion upon the rails, or in other words of causing it to run either backward or forward at will; this was first done and still is done in many stationary and marine engines, by means of loose excentrics whose position upon the axle or crank shaft, in front or behind the crank, is determined by cams or catches fixed upon the shaft, the act of starting in reversing being accomplished by shifting the valve directly with hand gear. This system of loose eccentrics was found to be too cumbrous for locomotives where the available space is extremely limited, and at the same time it was too abrupt and easily deranged; for these reasons it was soon displaced by the more substantial plan known as Carmichael's valve gear

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(Fig. 1, Plate 23), in which the eccentrics were fast upon the axles, and the eccentric rod ends were provided with a double fork intended to work in the studs of a double lever fixed upon the rocking or valve shaft; they were placed in forward or backward gear by means of a reversing shaft and levers which caused them to engage either the upper or lower stud, and thus the direction of the movement was readily changed by working one handle only; the forks were made wide enough to engage the studs in all positions of the valve, and Mr. Clark says that when the whole mechanism was well proportioned it preserved the lead of the valve both ways, or in other words, the fact of reversing the motion did not alter the relative position of crank and valve with regard to the periods of admission and release of steam. It seems, however, that this piece of mechanism, though a great improvement upon the old method, was soon found to be defective in that very point of preserving the lead both ways, since it was superseded, in 1837, by the method of four eccentrics introduced first by Hawthorn, in which each valve is provided with two fixed eccentrics keyed respectively before and behind the crank. (Fig. 2) illustrates this method, as carried into practice by the Stephensons, in whose arrangement both eccentric rods were hung underneath the stud of the valve lever, and were raised and lowered simultaneously by being hung from two reversing shafts, placed symetrically in front and behind the centre of the working shaft, but worked by one reversing handle only. This arrangement had the advantage of being self-balanced, and was worked very easily, though the presence of two reversing shafts was rather cumbrous. Sharp and Roberts' plan (Fig. 3) differed from Stephenson's, in that the forward and backward gabs were placed respectively above and below the stud of the valve rod lever, but still hung from two distinct reversing shafts. This arrangement is scarcely an improvement upon the former, though it might have been a decided simplification of it by removing one of the reversing shafts, and it is to be wondered that the proverbial ingenuity of Mr. Roberts did not at once discover its superfluity here, as was afterwards done by Buddicom, of Rouen, whose valve gear is illustrated by (Fig. 4).

The problem of reversing the engine was now effectually solved and henceforward we find the ingenuity of man exerting itself to devise means for working the steam expansively.

The benefits of an increased lap and consequently of a slight expansive action, and an early release of the steam had been ascertained by practice upon the Liverpool and Manchester Railway since 1838, and the means of long and variable expansion were, therefore, at once sought in a considerable increase of the lap accompanied with variable travel of the valve. The first scheme which we meet with is John Gray's (Fig. 5) which was applied to some engines on the Liverpool and Manchester Railway in 1839. Here the eccentric rods were made to work in a slot lever, curved to the radius of the rods, and pivotting upon a fixed centre at one end, while the valve rod was attached to the other, and the travel of the valve was altered by raising or lowering the excentric rod; the engine was reversed, as before, by the use of two eccentrics which were thrown in and out of gear by means of a suitable arrangement of frames worked from one reversing handle, and made to engage into slot levers respectively commanding the forward and backward rods. This scheme, though it is cumbrous and complicated, and the action of reversing the engine difficult and abrupt, must be looked upon as the origin of the modern valve gear, for Williams' motion (Fig. 6) is a natural simplification of the former, but being impracticable in its arrangement, was finally put into its permanent and elegant shape (Fig. 7) by the Stephensons's, with whom, therefore, it may properly be said that the locomotive engine originated, and by whom it received its finishing touch.

Various schemes of valve gearing have been at different times proposed to supersede what is termed the Link motion, some of them with a pretence at simplification, and others with the object of improving the action of the valve with regard to variable expansion and release of steam; the greater part of them however have met with little or no success. The objects of most attempts at simplification have been to dispense either with both or at any rate with one eccentric, and among these one of the most remarkable is Hawthorn's (illustrated by Fig. 8), in which the work of distributing the steam was performed by the connecting rod itself: a slide block was fixed to the latter in a suitable position of its length and was made to slide in a slotted link which transmitted the vertical motion of the block to the valve levers. The method of reversing was substantially the same as in Carmichael's gear, but the lead of the valve was regulated by giving the slotted link a certain incline either from the cylinders or towards them according as the engine was to run forward or backward; this very ingenious scheme was certainly much more difficult of adjustment than the method of two eccentrics and was much more complicated; on that ground also has it not met with much success although it yielded good results so far as regards the distribution of the steam.

In schemes for suppressing one eccentric, this object generally was attained by making the remaining eccentric movable either laterally in a helical groove, or transversely upon the axle, which was made square on that account; this however was only returning to the old method of loose eccentrics, long since condemned, and it is therefore no matter for wonder that its reproduction in a somewhat altered shape should have met with no better success.

The schemes of variable expansion generally consisted of two valves, it being the work of one valve to cut off the steam at various periods of the stroke, while the other distributed it into the cylinder in the ordinary manner.

Among these is to be noted Meyer's expansion gear (Fig. 9) which was frequently applied to locomotives upon the continent,—before the good results obtained by the link motion were properly known,—and which is still very extensively used in stationary engines: here the distributing valve was provided with ports in the same way as the cylinder, and upon the back of it were two expansion blocks whose distance from each other was regulated from the outside by means of a right and left handed screw, and which were put in motion sometimes by the cross head of the piston rod, sometimes by a distinct eccentric parallel with the crank; when therefore the distributing valve was at the end of its travel, the expansion blocks were only in the middle of their travel, and the degree of expansion was varied by shifting them either from or towards the centre of the valve face by means of the screw before mentioned. The distributing valve was worked by the ordinary double eccentric and gab motion. This expansion gear accomplishes its intended object very well indeed, but has the disadvantage of requiring an amount of space which in locomotives cannot be well afforded, nor has it the same claims to simplicity as the link motion, by which, for these reasons it has been superseded.

Before entering into the analysis of different kinds of link motions we will explain to our readers the general mode of distributing steam by means of the slide valve, and point out the defects of the old valve together with the means employed to remedy them, without however entering into a tedious explanation of technical nomenclature, the knowledge of which is now very generally diffused. The problem of distributing steam into a cylinder in order to communicate a reciprocating motion to the piston very naturally presents itself, at a first glance, in the following manner:—

1st. To let the steam enter the cylinder, when the piston has reached the end of its stroke, and to allow that steam, in front of which the piston is moving, to remain in the cylinder until the piston has reached the opposite end of the stroke, or in other words, to allow the entire volume of steam admitted to fill the extreme capacity of the cylinder.

2nd. To begin exhausting this steam just when the piston starts upon its return stroke, and to allow the exhaust to continue during the whole period of the return stroke.

It is easy to perceive from these conditions of the problem, that the admittance of steam at one end of the cylinder and the release of the steam which has done its work at the other end are two simultaneous events, and from inspection of the old valve diagram (Fig. 1, Plate 232) it will be perceived also that, under these circumstances, the valve faces just cover the steam ports with only a nominal lap to make sure that the steam does not enter at both ends of the cylinder at the same moment; the valve also is at mid stroke when the piston is at the end of its stroke.

Practice however, as we have had occasion to mention already, soon revealed the fact that these are not the true conditions of the problem, if the engine is to perform its work efficiently and economically. The complete exhaustion of the steam in the first place cannot be accomplished instantaneously, and since under the above conditions the exhaust is allowed to commence only when the piston begins its retrograde movement, the latter meets with an amount of back pressure seriously prejudicial to the economic interests of the engine; but if the steam were released sometime previous to the piston reaching the end of the stroke a great amount of back pressure would be avoided, though at the same time also a certain amount of useful work would be lost, owing to the untimely fall of pressure occasioned by this early release of the steam, and the question presents itself, does the gain upon back pressure warrant the loss of useful work thus obtained?

The question could be readily answered from a comparison of indicator diagrams taken from engines working respectively with the old and the modern valve, but the fact of the gain seems to be so evident that even Mr. Clark, who enters very minutely into the behaviour of steam in the cylinder, has not deemed it necessary to draw this comparison for the satisfaction of the minds of his readers, and the only means at our disposal to establish the desired parallel, is a record of the comparative consumption of fuel with progressive modifications of the valve, a summary of which we reproduce in the subjoined table.

Gross average consumption of coke per mile.

49 lbs.	old valve $\frac{1}{16}$ lap 1839.
36 lbs.	valves with $\frac{1}{8}$in. lap.
32 lbs.	valves with $\frac{3}{16}$in. lap.
28 lbs.	valves with 1in. lap.
22 lbs.	ditto ditto*

* With increased care in fixing.

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The reduction in the consumption of fuel here shown, however, is not solely due to the reduction of back pressure, but arises also from the other sources of gain which we yet have to enumerate.

Another consequence of the construction of the old valve was that the steam was allowed to flow into the cylinder during the whole period of the stroke, and hence the benefits of the expansive properties of steam were lost altogether, although they had not remained unknown and were largely realised in the stationary engine. By inspection of the diagram the valve with one inch lap (Fig. 2, Plate 232), it will be seen that the steam works expansively during a period of three-elevenths of the stroke and the relative efficiency of steam at this degree of expansion is 1·32 which, in a great measure, accounts for the saving of fuel recorded in the above table. It will be seen also from the diagram that the steam is released at a period of two-twentieths of the stroke, which gives it sufficient time to clear the cylinder by the time the piston has reached the end of the stroke. Finally the valve is given a slight amount of lead varying from one-quarter to three-eighths, to admit the steam a short time before the piston has reached the end of the stroke with the object of filling the steam ways and of providing a spring, against which the momentum of the parts of machinery in motion wastes itself, thus deadening the shock which would inevitably be occasioned by any play which may exist between them, and avoiding their undue wear and untimely destruction.

(To be continued).

USEFUL NOTES AND FORMULÆ FOR ENGINEERS.

(Continued from page 269, December, 1862.)

SECTION VIII.

In this section we purpose treating of the flow of water, under various circumstances, to the end that we may deduce from our investigations formulæ which may be applied to practical purposes; as the construction of canals, weirs, pipes, etc.

The weight of water is taken at 10lbs. to the gallon, or 62·5lbs. or 1000 ounces per cubic foot, we shall, however, use only the cubic foot in this treatise.

The measure of gravity, although it varies slightly for different parts of the earth's surface, is usually taken at 32·182ft., this being the velocities acquired by a heavy body after falling freely for one second, the space through which it falls in the first second being equal to 12,091ft., and the above measure of gravity is denoted by 1.

According to the principles of uniformly accelerated motion, the velocity acquired during the fall of a heavy body are as the times occupied in acquiring them.

Let v = the velocity acquired.
t = the time occupied.
g = the velocity acquired in one second.

Then

$$v = g\,t,$$

also the spaces passed through are as the squares of the times occupied in passing through them.

Let h = height of fall.
t = time occupied in falling.
$\frac{1}{2}g$ = space fallen through in one second.

Then

$$h = \frac{g\,t^2}{2}$$

taking the value of b from this equation, and substituting it in the first we have,—

$$v = \sqrt{2\,h\,g} \text{ and } h = \frac{v^2}{2\,g}$$

since

$$g = 32{\cdot}182 \text{ feet}$$

$$\sqrt{2g} = 8{\cdot}0227$$

and

$$\frac{1}{2g} = 0{\cdot}15536$$

consequently,

$$v = 8{\cdot}0227\sqrt{h}$$

and

$$h = 0{\cdot}015536\,v^2$$

GENERAL PRINCIPLES OF THE FLOW OF WATER.

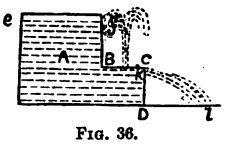

FIG. 36.

Let A (Fig. 36) be a vessel kept constantly full of water up to $e\,f$.

If an orifice is made in the horizontal surface B C, the fluid will pass out as a vertical which will rise to nearly the level of $e\,f$, and it would be quite that level were it not for certain retarding influences, as the resistance of the air, etc.

By the first principle of dynamics, in order that a body may rise vertically to a certain height, the velocity imparted to it, at starting, must be equal to that which it would have acquired in falling freely through the same distance. Therefore as the fluid particles, which pass out at the orifice in B C, are raised to the height B f, they must have velocities due to that height, which is the height of the water in the reservoir, above the orifice.

In like manner, if an orifice k be made on a vertical face, the velocity of exit of the particles will be found from certain relations between the lines D k, D l, to be that due to the height $k\,f$, and it would pass out with a velocity due to D f, if an orifice were opened in the bottom of the vessel.

If we call v the velocity of issue, and H the height of the water level above the orifice, we shall have,

$$v = \sqrt{2\,g\,h}$$

We have seen that the water does not quite attain the level of water in the reservoir, and if a tube was fitted to the orifice it would rise still less high.

Let n be the ratio between the height of the jet, and that of the reservoir for a tube of a certain form, H and H′ two heights of the reservoir and v, v' the corresponding velocities, then,

$$v = \sqrt{2\,g\,n\,\mathrm{H}}, \text{ and } v' = \sqrt{2\,g\,n\,\mathrm{H}'}$$

whence,

$$v : v' :: \sqrt{\mathrm{H}} : \sqrt{\mathrm{H}'}$$

that is to say, the orifices being of the same form the velocities are as the square roots of the heads.

This law applies to fluids of all kinds, such as oil, mercury, and the aeriform, so that the velocity, with which each of them passes over, is independent of its nature and density, and depends only on the head.

To the pressure which a fluid contained in a vessel exerts by its own weight on the orifice, may be added that of a foreign pressure, let this pressure be produced by a body P, acting on a surface s, then to find the additional head of water to which it is equal, replace it by a column of water of equal weight, having a base equal to s, the height of the column will be the additional head.

If we call h the head of water in the reservoir, and h' the additional head, the velocity will be,

$$= \sqrt{2\,g\,(h + h')}$$

We call the discharge of an orifice the volume of fluid which runs out of it in a second.

If the mean velocity were that which is due to the whole head, this velocity would be

$$= \sqrt{2\,g\,\mathrm{H}}$$

if, at the same time, the particles passed out from all points of the orifice, and in parallel lines, the volume discharged would be equal to a prism, having the orifice for its base and the velocity for it height; it would be, calling S the area of the orifice,

$$= \mathrm{S}\sqrt{2g\mathrm{H}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

This is the theoretic discharge, but actual discharge is always less. This diminution of the discharge is produced in some cases by a diminution of the section of the prism of water, as in orifices in thin plates; in others it is produced by diminution of velocity, as in cylindrical tubes.

The actual discharge will in all cases be less than the theoretic, and to reduce the latter to the former, we must multiply it by a fraction. Let m represent this fraction; then, if Q is the quantity discharged,

$$\mathrm{Q} = m\,\mathrm{S}\sqrt{2\,g\,\mathrm{H}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

and if Q^1 is the volume discharged in any number of seconds, N,

$$\mathrm{Q}' = m\,\mathrm{S}\,\mathrm{N}\sqrt{2\,g\,\mathrm{H}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

The diminution of discharge, whether it proceed from diminution of the

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section or of the velocity of the vein, is always the consequence of the contraction which the vein experiences on passing through the orifice, wherefore m is called the co-efficient of contraction.

We will now show the cause of the contraction and its effects.

If we take a transparent vessel, having an aperture in one side through which the contained water is allowed to flow, and render the motion of the fluid particles visible by disseminating a substance of equal specific gravity in fine powder through the liquid, we shall find that after leaving the orifice, the water does not proceed in a cylindrical stream, but the particles approach the orifice from various directions, converging and passing through the aperture with an accelerated motion; the convergence of the particles of water causing a contraction without the orifice, $a\ b\ c\ d$ (Fig. 37) shows the form of the contracted vein, being a solid produced by the revolution of the curve $a\ c$ round the axis $e\ f$; $a\ b$ is the diameter of the orifice, $c\ d$ the diameter of the cylindrical stream after contraction, $e\ f$ the distance from the orifice to the section at which the stream becomes cylindrical; the values of these dimensions, found by actual measurement, are,

Fig. 37.

$$\text{If } a\ b = 1000.$$
$$c\ d = 787.$$
$$e\ f = 390.$$

from which we may obtain the co-efficient of contraction.

The ratio between the diameters before and after contraction being 0·787, the ratio between the sections will be the square of 0·787 or 0·619, which will be the value of m; substituting this in equation (2), we have,

$$Q = 0{\cdot}619\ S\ \sqrt{2\,g\,H} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

This value of m is very near the truth, as indicated by experiment.

Flow through Orifices and Ajutages.

We will first consider the flow through an orifice in a thin partition. The co-efficient of reduction of the theoretic to the actual discharge is determined by measuring the volume of water discharged in a given time, and comparing it with the calculated discharge.

The greatest co-efficient obtained from a number of experiments by Castel and others on circular tubes was 0·692, and the least 0·617; on square orifices the maximum co-efficient was 0·655, and the minimum 0·616. We have hitherto considered that the fluid arrives equally at all parts of the orifice, but it is not always so; for instance, if the aperture be at the bottom of a vertical side, and its lower in the plane of the bottom of the reservoir, the contraction is destroyed on that side, and the discharge is greater.

Some experiments have been made by M. Bidone for the purpose of ascertaining the increment of discharge corresponding to partial destruction of the contraction, the mean of the experiments giving for the increment of discharge that of the free orifice being taken as unity,

$$1 + 0{\cdot}152\ \frac{n}{p}$$

in which n represents the length of the perimeter at which the contraction is suppressed, and p the length of the whole perimeter.

The greatest error of this formula was $\frac{1}{75}$, we may, therefore, adopt for the value of the discharge from rectangular orifices, when the contraction is suppressed on a part of the perimeter,

$$Q = m\ S\ \sqrt{2\,g\,H}\left(1 + 0{\cdot}152\ \frac{n}{p}\right) \quad \ldots\ldots\ldots\ (5)$$

for square orifices.

The mean of the experiments on circular orifices gives,

$$Q = m\ S\ \sqrt{2\,g\,H}\left((1 + 0{\cdot}128\ \frac{n}{p}\right) \quad \ldots\ldots\ldots\ (6)$$

Interior tubes reduce the co-efficient of contraction very considerably on account of the effluent particles approaching the orifice in more opposite directions than in the case of an orifice in a thin plate; Borda by means of an interior tube so arranged that the effluent water in no way touched the sides of the tube, reduced the co-efficient of contraction to 0·515.

The limits of the co-efficient of contraction for orifices of all kinds, with or without ajutages will be, 1 and 0·50, which may be approached very nearly but never attained, for orifices in a plane side they seldom descend below 0·60, or rise above 0·70, and in practice they are usually confined between 0·60 and 0·64; as a mean approximate term 0·62 is generally taken, whence we have for a circular orifice, whose diameter is represented by d,

$$Q = 0{\cdot}62\ S\ \sqrt{2\,g\,h}$$
$$= 3{\cdot}9066\ d^2\ \sqrt{H} \quad \ldots\ldots\ldots\ (7)$$

We may ascertain the real velocity of discharge under any head by measuring the height to which the fluid will rise vertically, and if h be the height to which it rises, the velocity at the orifice will be

$$\sqrt{2\,g\,h}$$

if H is the head of water in the reservoir, h differs from H, 1, 2, 3, &c., hundredths of the square of its value, according as H is 1, 2, 3, &c., and the velocities being as the square roots of the heights, the actual velocities will differ in the same cases only 1, 2, 3, &c. half hundredths of the theoretical velocity.

Another method of determining the actual velocity indicates still less difference, it is as follows:—

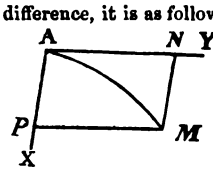

Fig. 38.

When a body is thrown in any direction A Y (Fig. 38) with a certain velocity, by the combined influence of that force and of gravity it describes the curve A M, if the velocity and consequently the resistance of the air is not very great, that curve is a parabola. If v is the velocity with which the body is impelled along A Y, and t the time which would be occupied in reaching N if no other force acted upon it, the motion would be uniform, and we should have $A\ N = t\ v$. If, on the other hand, the force of gravity had acted alone, it would have descended from A to P, and we should have had

$$A\ P = \frac{g\,t^2}{2}$$

Complete the parallelogram A P MN; at the end of the same time it wil arrive at M, having described the arc A M, $A\ P = x$ will be its abscissa, and $M\ P = y$ will be its ordinate, then

$$x = \frac{g\,t^2}{2}$$

and

$$y = v\,t,$$

taking the value of t from the latter equation and substituting it in the first, we have,

$$x = \frac{g\,y^2}{2\,v^2}$$

or

$$y^2 = \frac{2\,v^2\,x}{g},$$

or calling h the height due to the velocity v, and remembering that

$$\frac{v^2}{2\,g} = h$$

$$y = 4\,h\,x$$

an equation to a parabola, of which $4\,h$ is the parameter. Hence a heavy body impelled by any force of projection, describes a parabola whose parameter is four times the height due to the velocity of projection.

This law applies to jets of water as well as to solid bodies, and determining the actual velocity by this method. Bossut found the ratio of the actual to the theoretic velocity in two experiments to be 0·974, and 0·980; Michellotti found it, in three experiments, to be 0·993, 0·988, and 0·983. The difference between the two velocities increases with the head, and it should be so, as the cause of this difference, the resistance of the air, varies as the square of the velocity, and consequently nearly as the head.

If the water contained in the reservoir instead of being at rest, were moved towards the orifice with a velocity u, we should have

$$Q = m\ S\ \sqrt{2\,g\left(h + \frac{u^2}{2\,g}\right)} = m\ S\ \sqrt{2\,g\,h + u^2} \quad \ldots\ldots\ldots\ (8)$$

We will now consider the flow of water through ajutages. Cylindrical ajutages give a greater discharge than orifices in a thin side, provided the length of the ajutage exceeds the length of the contracted vein; it should be two or three times the diameter. Under these circumstances the vein after contraction, expands and fills the passage being attracted by the sides of the tube.

The diminution of the actual discharge is caused by diminution of velocity, and the mean coefficient is 0·82, thus,

$$Q = 0{\cdot}82\ S\ \sqrt{2\,g\,H} = 5{\cdot}1668\ d^2\ \sqrt{H} \quad \ldots\ldots\ldots\ (9)$$

The discharge through converging conical ajutages is greater than the preceding, although a contraction takes place without the tube.

The angle of convergence corresponding to the greatest discharge is from 13° to 14°.

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The co-efficient of discharge which corresponds to the angle 13°, is about 0·953.

Conical diverging ajutages give the greatest discharge, but as they are but little used, we shall pass over them, although they present some interesting phenomena.

FLOW OF WATER UNDER VERY SMALL HEADS.

When the head over the centre of the orifice is very small, compared with the height of the orifice, the mean velocity of the fluid vein, or the velocity by which the area of the orifice is to be multiplied to give the discharge, is not that of the centre line of the vein.

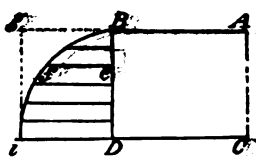

FIG. 39.

Let A B C D (Fig. 39,) represent a vessel kept full of water; and let there be in the vertical face B D, a series of very small apertures, of which D is the lowest. Let H equal the height B D, then the velocity of the particles passing out at D,

$$= \sqrt{2gH}$$

and if D *i* be made equal to that quantity it will represent the velocity. For any other point *e*, whose distance below the level of the reservoir is B *e*, or *x*, the line *e f* or *y* will represent the velocity, so that

$$y = \sqrt{2gx}$$

or

$$y^2 = 2gx,$$

which is the equation of a parabola whose parameter is 29.

Suppose now that instead of a number of small openings in the face B D there had been a rectangular slit whose breadth is *b*, it is evident the discharge will be equal to the prism having *b* for its length, and the parabolic segment B *f i* D for its base.

According to the properties of the parabola, the parabolic segment is equal to two thirds of the rectangle B *g i* D, which rectangle is equal to H × *b*; the discharge through the rectangular slit will therefore be

$$= \tfrac{2}{3} b H \sqrt{2gH} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

The discharge through a similar slit whose height is D *e*, will evidently be equal to the difference between the discharges when the heights of the slits are H and B *e*, call this latter *h*, then the discharge,

$$= \tfrac{2}{3} b \sqrt{2g} \left(H\sqrt{H} - h\sqrt{h} \right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (11)$$

these equations give the theoretic discharge, and to reduce them to the actual discharge they must be multiplied by the co-efficient of contraction, which in this case varies from 0·60 to 0·70.

FLOW OF WATER OVER WEIRS.

Let there be made a rectangular opening B C (Fig. 40) at the top of the basin A B C D, the basin being kept constantly full of water; this opening is called a weir.

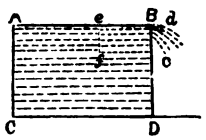

FIG. 40.

The surface of the water before reaching the weir, and starting from a point *e*, is inclined along the arc *c d*; so that its height above the sill will not be B *c*, but *d c*. If we follow this investigation it will lead to the conclusion that discharge would be the same as in the case of a rectangular orifice, whose upper edge is at *d*, the water level being continued to B without inflection; it is, however, more correct to consider the discharge as proceeding from a rectangular orifice, whose height is equal to *f e* or B *c*; hence we have from equation 10 (*p*)—

$$Q = \frac{2}{3} b H \sqrt{2gH}$$

for the theoretic discharge; or

$$Q = \frac{2}{3} b H m \sqrt{2gH}$$

$$= 5{\cdot}3484\, m\, b\, H \sqrt{H} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (12)$$

for the actual discharge.

We have hitherto considered the water to be at rest above the weir, but it very frequently happens that it arrives at the weir with a certain velocity. Let *u* represent the velocity of arrival; 0·0155 u^2 will be the height due to that velocity, and we shall have for the real velocity at the exit—

$$\sqrt{2g\left(\tfrac{4}{9} H + 0{\cdot}015536\, u^2\right)}$$

and consequently,

$$Q = 5{\cdot}3484\, m\, b\, H \sqrt{H + 0{\cdot}035\, u^2} \quad \ldots\ldots\ldots\ldots \quad (13)$$

In some experiments upon the flow over weirs, the value of *m* varied from about 0·60 to 0·70.

MOTION OF WATER IN CANALS.

Gravity is the sole force that acts upon a mass of water left to itself in a bed of any form; so that as long as the surface of the water is horizontal no motion will take place; but if the surface is at all inclined, motion will immediately take place. Hence the principle that the motion of particles in a watercourse is due wholly to the slope at the surface, and it is this slope which enables gravity to act.

If the surface of the water in a canal makes an angle α with the horizon, that part of the gravitating force which causes motion will be represented by

$$g \sin. \alpha$$

which will be the velocity acquired in one second. This velocity will continually increase if no other resistance is met with; this, however, is not the case, for the motion becomes uniform after a very short time.

We will now consider the nature of the resistance which produces this phenomenon. When water passes over the surface of a body, there being no repulsion between the two substances, it wets the surface—that is to say, a thin layer of water is attracted and retained, the particles of which again attract the passing particles of water, retarding their motion; and this attraction extends to the centre lines of particles, but continually decreasing from the perimeter to the centre. This constitutes fluid friction, which is independent of the pressure of the water, being proportional to the wetted surface, and also to a quantity depending upon the velocity. The friction will be influenced by the velocity in two ways: first, the force with which the particles are attracted will be as the velocity, and the number attracted will also be as the velocity, the total retardation being as the square of the velocity. This would give $a v^2$ for the retarding influence, *a* being a constant to be found by experiment; but practice shows that the expression

$$a' (v^2 + b v)$$

will be a nearer approach to the truth. Besides the two quantities already named as regulating the retardation, it is affected by a third, the section area of the stream, to which it is inversely proportional; therefore the total resistance

$$= \frac{c}{S} a (v^2 + b v)$$

in which *c* represents the contour, *s* the sectional area, and *a b* are constants. We have for the value of *a* and *b*, from very extensive observations of Eytelwein on canals and rivers,

$$a = 0{\cdot}0035855$$

$$b = 0{\cdot}217785$$

As the value of $a\, b\, v$ will be very small, it may be omitted in practice, and the resistance considered as

$$= \frac{c}{S} a v^2$$

To find the velocity we must equate the accelerating to the retarding forces; the accelerating force is equal to the sine of the angle of inclination multiplied by the force of gravity; the retarding force is the resistance of friction; therefore if

h = height of level of one point of the canal above any other.
l = distance between these points.
c = wetted perimeter.
s = sectional area.

$$\frac{h}{l} \times g = a \times \frac{c}{s} \times v^2$$

$$v^2 = \frac{g}{a} \times \frac{s}{c} \times \frac{h}{l}$$

but,

$$\frac{g}{a} = 10{,}000$$

therefore,

$$v = 100 \sqrt{\frac{h}{l} \times \frac{s}{c}}$$

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v being the velocity at the lower point; the quantity of water delivered at this point will be

$$Q = 100\, s \sqrt{\frac{h}{l} \times \frac{s}{c}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Motion of Water in Pipes.

We here consider the case of closed pipes such as are used for conducting water from one place to another; these conduit pipes usually run full under the pressure.

The motion of water in pipes is similar to that in canals, and the formula (equation 14),

$$Q = 100\, s \sqrt{\frac{h}{l} \times \frac{s}{c}}$$

will apply to the discharge; but for pipes running full

$$s = d^2 \times \cdot 7854$$

$$c = d \times 3 \cdot 1416$$

$$\therefore \frac{s}{c} = \frac{d^2 \times \cdot 7854}{d \times 3 \cdot 1416} = \frac{d}{4},$$

in which d is the diameter,

$$\therefore Q = 38 \cdot 27 \sqrt{\frac{h}{l} \times d^5}$$

which is the discharge in cubic feet per second: although we have throughout given the discharges in cubic feet per second we shall, in this case furnish the value of the discharge per minute;

Let Q' = discharge in cubic feet per minute.

$$Q' = 2356 \sqrt{\frac{h}{l} \times d^5} \quad \ldots\ldots\ldots\ldots\ldots\ldots (15)$$

or stating it in logarithms,

$$\log. Q' = \frac{1}{2}\left\{6 \cdot 744 + \log. h + 5 \log. d - \log l\right\}$$

These formulæ do not take the resistance of bends into consideration; we will therefore proceed to the investigation of this kind of resistance.

Let a stream of water be proceeding in the direction A B (Fig. 41) and at the point B let there be a sudden change in the direction of the conduit; then draw A D at right angles to C D, the direction in which the stream will be turned, and let the angle A B D be represented by α; then if A B represent the velocity of the stream when it arrives at B, the velocity in the direction C B will be

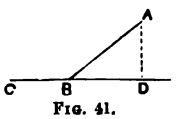

Fig. 41.

$$= v \cos. \alpha = B\,D$$

the loss will evidently be represented by the difference between the velocities before and after passing the point B, or by

$$A\,B - B\,D = v - v \cos. \alpha$$

$$= v\,(1 - \cos. \alpha) = v \text{ versin. } \alpha$$

Hence the loss caused by a sudden bend, is that represented by the versine of the angle made by the two directions.

In the case of a circular bend the loss of velocity is extremely small, as the particles running close to the sides of the tubes suffer no loss; although the centre lines of particles will be reflected from side to side of the tube all round the curve. From experiments on the resistance of curved bends, Dubuat concluded, that the value of that resistance is proportional to the square of the velocity, to the number of angles of reflexion and to the squares of their sines, the mean co-efficient 0·00375. So that if v be the velocity, n, n^1, &c., the number of the angles of the same magnitude, α, α^1 the magnitudes of the angles, the resistance will be

$$= 0 \cdot 00375\, v^2\,(n \sin.^2 \alpha + n^1 \sin.^2 \alpha^1 + \ldots.)$$

or, s^2 being the sum of the squares of all the sines, and D the diameter of the pipes

$$= 0 \cdot 006079\, \frac{Q^2}{D^4}\, s^2$$

A resistance, and consequently a reduction of velocity and discharge will be produced by sudden enlargements or contractions of the conduit; however, as the conduit should not have enlargements or contractions, and as the formulæ for the resistance opposed by them, are not satisfactory we shall not give formulæ for the value of this resistance.

ERICSSON'S "MONITOR."

Most of our readers are doubtless aware of the *Monitor* having been totally lost (the details of the loss will be found in another column). The accompanying illustrations, figures 1 and 2, represent this ill-fated vessel as designed and constructed by Capt. Ericsson, without the extra plating afterwards added. Figure 1 being a side elevational view, and fig. 2 a transverse section to an enlarged scale through centre of the revolving cupola.

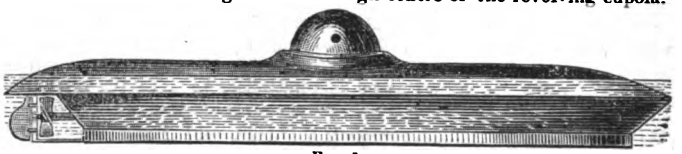
Fig. 1.

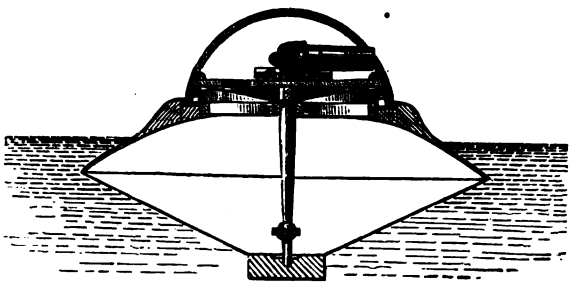
Fig. 2.

We will not here enter a discussion of the merits of the rival claims of Capt. Ericsson and Capt. Coles as to the originality in the invention of this class of vessels and the cupola; as though, doubtless, Capt. Coles may possibly deserve some credit for endeavouring to *improve* upon Ericsson, still that the originality of design of the *Monitor* is due to Ericsson, we think there can be no doubt whatever.

The following is an extract of a communication from Capt. Ericsson upon the subject of this invention, and forwarded to the Emperor of the French in September, 1854.

"*New System of Naval Attack.*—The vessel to be composed entirely of iron. The midship section is triangular, with a broad, hollow keel, loaded to balance the heavy upper works. The ends of the vessel are moderately sharp. The deck, made of plate iron, is curved both longitudinally and transversely with a spring of 5 feet; it is made to project 8 feet over the rudder and propeller. The entire deck is covered with a lining of sheet iron, 3 inches thick, with an opening in the centre 16ft. diameter. This opening is covered by a semi-globular turret of plate iron, 6 inches thick, revolving on a column and pivot by means of steam power and appropriate gear work. The vessel is propelled by a powerful steam engine and screw propeller. Air for the combustion in the boilers and for ventilation within the vessel, is supplied by a large self-acting centrifugal blower, the fresh air being drawn in through numerous small holes in the turret. The products of the combustion and impure air from the vessel are forced out through conductors leading to a cluster of small holes in the deck and turret. Surrounding objects are viewed through small holes at appropriate places. Reflecting telescopes, capable of being protruded or withdrawn at pleasure, also afford a distinct view of surrounding objects. The rudder stock passes through a water-tight stuffing-box so as to admit of the helm beng worked within the vessel. Shot striking the deck are deflected, whilst shell exploding on it will prove harmless. Shot (of cast iron) striking the globular turret, will crumble to pieces or are deflected. This new system of naval attack will place an entire fleet of sailing ships, during calms and light winds, at the mercy of a single craft. 'Boarding,' as a means of defence, will be impracticable, since the turret guns, which turn like the spokes in a wheel, commanding every point of the compass at once, may keep off and destroy any number of boats by firing slugs and combustibles. A fleet at anchor might be fired and put in a sinking condition before enabled to get under weigh. Of what avail would be the 'steam guard ships' if attacked on the new system? Alas for the 'wooden walls' that formerly 'ruled the waves.' The long range Lancaster gun would scarcely hit the revolving iron turret once in six hours, and then, six chances to one, its shot or shell would be deflected by the varying angles of the face of the impregnable globe. When ultimately struck at right angles, the globe, which weighs upwards of 40 tons, will be less affected by the shock than a heavy anvil by the blow of a light hammer; consequently, the shot would crumble to pieces, whilst the *shell* would strew the arched deck with harmless fragments. During contest the revolving turret should be kept in motion, the port-holes being turned away from the opponent except at the moment of discharge, which, however, should be made during full rotation, as the lateral aim in close quarters requires but little precision."

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

Date each day, ending at Noon.	PADDLE ENGINES. Revolutions of Engines each day.	Average Revolutions per minute.	Average Pressure of Steam in Engine-room.	Tons of Coal used each day.	SCREW ENGINES. Revolutions of Engines each day.	Average Revolutions per minute.	Average Pressure of Steam 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.	GENERAL REMARKS.
			lbs.	Tons			lbs.	Tons	Tons	K.	K.	K.				inches.	deg.	deg.		
	19	9·0	19	20	16	31·0	16	25	45	28	28	22				...	0	0	0	
Jan. 5 ...	942	9·0	19	20	4,100	31·0	16	25	45	28	28	22	Steering by the land.	68·10 W.	Various.	29·61	0	0	0	At 10 A.M. started engines ahead full speed. At 10.50 A.M. stopped engines to discharge pilot and stevedores men. At 11 A.M. started engines ahead full speed.
Jan. 6 ...	12,960	9·0	22	120	43,780	31·0	17	150	270	317	319	245	40·50 N.	68·10 W.	Various.	29·61	0	0	0	At 7.30 P.M. stopped engines to discharge pilot off Montauk point. At 7.45 P.M. full speed.
Jan. 7 ...	12,393	9·0	20	136	45,480	32·2	17	156	292	314	325	265	43·41 N.	63·9 W.	N. E. by E. ½ E.	29·60	7	8	6	Strong wind and heavy sea running; square sails set.
Jan. 8 ...	11,485	8·5	19½	126	43,920	32·0	17	144	270	300	320	275	45·30 N.	58·19 W.	E. ¼ N.	30·19	6	7	4	Stopped screw engines 1 hour and 30 minutes to repair brasses of crank in tunnel.
Jan. 9 ...	12,231	9·0	20	134	44,940	32·6	17½	150	284	311	325	246	46·26 N.	52·12 W.	E. by N. ¼ N.	30·41	3	5	5	Stopped paddle and screw engines 45 minutes to take soundings.
Jan. 10 ...	12,630	9·0	20	126	44,060	32·0	16	147	273	315	325	260	47·40 N.	46·4 W.	E. N. E.	30·27	3	5	6	Stopped paddle and screw engines 20 minutes to put a corpse over board.
Jan. 11 ...	11,692	9·0	20	118	44,580	32·0	16	148	266	313	323	264	49·20 N.	39·42 W.	E. ¼ N.	30·31	7	9	5½	Strong beam wind and heavy sea; fore and sails set.
Jan. 12 ...	12,568	8·9	20	124	46,260	33·6	17½	152	276	300	339	266	49·42 N.	33·19 W.	E.N. by ¼ N.	30·37	5	7	5	Light fair wind; square sails set.
Jan. 13 ...	13,494	9·6	20	139	46,670	33·3	17½	160	299	330	333	270	50·20 N.	26·30 W.	E. ¼ N.	30·41	4	5½	4	Light fair wind; square sails set.
Jan. 14 ...	13,821	9·7	20	141	46,690	33·0	17½	158	299	341	339	290	51·10 N.	18·40 W.	E. ¼ E.	30·57	3	5	3	Light head wind; swept tubes of paddle boilers.
Jan. 15 ...	14,065	10·0	20	140	47,060	33·4	17½	160	300	350	340	280	51·12 N.	11·32 W.	E.	30·60	2	3	4½	Light head wind; swept tubes of screw boilers.
Jan. 16 ...	14,251	10·0	20	134	46,210	33·7	17½	165	289	350	333	300	52·56 N.	5·30 W.	Various.	30·60	0	2	4	Light head wind; sea smooth.
Jan. 17 ...	5,616	11·0	20	66	18,320	35·0	17½	62	113	128	130	93	Steering by the land.			30·50	0	0	0	Strong head wind; sea smooth. At 5.30 P.M. stopped paddle and screw engines. At 6.35 P.M. stopped paddle and screw engines to take pilot on board. At 7. P.M. started paddle and screw engines ahead half speed. At 8.45 P.M. arrived off Bell Buoy.
Total	146,158	9·3	20	1514	521,940	32·6	17·25	1767	3281	3695	3759	3078	...	...	...	...	...	...	...	Actual time steaming, 11 days, 3 hours. All particulars of engines taken up to this time.

Indicator out of order; density of water in boilers 1½; vacuum in paddle engines, 25; vacuum in screw engines, 25; extreme diameter of paddle wheels, 50 ft.; effective diameter 48ft. = 150·79 ft. each revolution; pitch of screw, 44ft.; average distance run per hour 11·52 knots; immersion on leaving New York, 25 ft. 2 in. forward, 29 ft. 11 in. aft.; immersion on arrival at Liverpool, 21 ft. 3 in. forward, 28 ft. 6 in. aft.; slip of paddle wheels 20·4 per cent.; slip of screw, 22·12 per cent.; average daily consumption of coal by paddle engines, 136·8 tons; ditto by screw engines, 158 tons; total daily consumption, 294·8 tons. (Signed) J. ROBISON, Chief Engineer.

INSTITUTION OF CIVIL ENGINEERS.

ON THE HOWNES GILL VIADUCT, ON THE STOCKTON AND DARLINGTON RAILWAY.

BY MR. W. CUDWORTH, M. INST. C.E.

This viaduct was situated near to the Consett Ironworks of the Derwent Iron Company, in the north-western part of the county of Durham, on what was formerly the Stanhope and Tyne Railway, an undertaking which came into the hands of the Stockton and Darlington Railway Company in the year 1844. Hownes Gill was a dry ravine 800ft. in width and 160ft. in depth, and originally the line was laid out with gradients corresponding with the natural contour of the ground, that on the west side being 1 in 2½ and that on the east side 1 in 3. The traffic was conveyed over these gradients for some years with little difficulty; but a large accession of of trade, due mainly to the discovery of the Cleveland ironstone, rendered greater facilities of transit imperative. It then became apparent, that the erection of a high level viaduct was indispensable; and as early as the year 1844, the Directors of the Stockton and Darlington Railway Company took steps with the view of ascertaining the probable cost of such a structure. It was not, however, until December, 1856, that a contract was entered into with Mr. John Anderson, to erect a viaduct of firebrick set in hydraulic mortar and the arches in cement, in eighteen months, and to uphold it for twelve months after completion, for the sum of £14,614. The design was prepared by Mr. T. Bouch (M. Inst. C.E.), and was subsequently approved, with some modifications, by the late Mr. R. Stephenson and Mr. G. P. Bidder.

The extreme length of the viaduct was 730ft., and its greatest height from the bottom of the inverts to the level of the rails 162ft. It had twelve semi-circular brick arches, each 50ft. span, 14ft. in length, and 2ft. 6in. in thickness. The inverted arches in the foundations, four in number, which were introduced, at the suggestion of Mr. Stephenson, so as to extend the bases of the three central piers until the weight scarcely exceeded 1 ton per superficial foot, had a versed sine of 14ft., were 38ft. in length, and 3ft. in thickness. The extreme height of the five loftiest piers, measured from the springing of the inverts to the springing of the arches, ranged from 114 to 110ft.; that of the six remaining piers diminished rapidly towards each end. Their length was 14ft. at the top, and 38ft. at the bottom, the latter dimension corresponding with that of the inverts. The piers, to within 15ft. of the inverts, were stayed by buttresses transversely to the line of the viaduct. At this point they were only 17ft. 6in. in length, but below this level the buttresses merged into the piers, when they together had a rectangular section 38ft. in length. The buttresses were 3ft. thick at the top, and 5ft. thick at the bottom; their projection from the piers being increased by offsets at intervals of 35ft. The piers, although light in their proportions, were reduced by recesses, 7ft. 3in. wide and averaging 3ft. 9in. deep, sunk in each side, so that the horizontal section of each pier with the buttresses was in the form of a double cross, the brickwork in the middle being only 2ft. thick. These recesses were not continuous, but were divided into three compartments in height, and by their adoption the amount of brickwork in each pier was reduced about 14½ per cent. Between the spandril walls, two internal parallel walls of stone were introduced to sustain a platform of flagging, on which the way beams and the ballast were carried. The way beams, which were of Memel timber, were at first secured to the internal walls by bolts; but as this plan was found to be objectionable, the nuts from the holding down bolts were removed, and a thickness of 6 inches of coke ballast was interposed between the way beams and the flagging. The parapet consisted of a substantial cast iron railing. The firebricks, which were of excellent quality, weighed 9lbs. 11ozs. each, and cost the contractor at the viaduct thirty-one shillings and twopence per thousand. The number used was 2,655,000. It was a gratifying fact that the work was completed without accident, and that not a single crack was to be found in the whole of the structure. The erection of the scaffolding, which was of a very light character, was considerably facilitated by the hoisting tackle being made to traverse a stout wire rope stretched across the gill, and firmly fixed at each side. When the arches were about to be turned, the piers were stayed by two parallel wire ropes stretched from end to end of the viaduct. The first brick was laid in February, 1857, and the first train passed over the viaduct in July, 1858. The cost of the structure amounted to £15,756, the contract sum having been increased by the additional depth of the foundations, by the adoption of a heavier

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parapet, and by other contingencies. Regarding the viaduct as an unpierced solid, its contents would amount to 61,910 cubic yards, and its cost would be five shillings and one penny per cubic yard.

The question of the relative cost of brick and iron viaducts was then alluded to, reference being made to two works of the latter description erected by Mr. Bouch on the South Durham and Lancashire railway. These viaducts consisted of three lines of trellis girders resting upon skeleton piers, formed of six cast iron columns, jointed at intervals of 15ft., and braced together by horizontal cast iron struts, and by vertical and horizontal tie bars of wrought iron. The clear spans between the piers were in all cases 48ft. The Beelah viaduct was 1000ft. in length, and 197ft. in extreme height. The Deepdale viaduct more nearly resembled the Hownes Gill in its proportions, being 740ft. length and 160ft. in extreme height. A comparison was therefore instituted between the probable cost of such an iron viaduct erected across the Hownes Gill valley, and one of brickwork, supposing both to be built to carry a double line of railway, and that the spread of the foundations was in each case adjusted to sustain a weight of 2½ tons per superficial foot, including the greatest moving load. The prices of the brickwork and of the masonry were taken from Mr. Anderson's schedule; those of the timber and ironwork were the prices actually paid to Messrs. Gilkes, Wilson, and Co., the contractors for the South Durham and Lancashire viaducts, minus a deduction of ten shillings per ton for the cost of cartage over country roads. With this adjustment it was found that the cost of the viaducts, calculated in this way, would be £20,681 for the brick structure, and £16,249 for that of iron. It was thought probable that the interest on the difference between these two amounts, say £222 per annum, would be absorbed in the periodical examination and painting of the iron, and the depreciation of the perishable timber platform; and that at the place referred to a brick viaduct would be, ultimately at least, as cheap as one of iron. If the viaducts were designed to carry a single line of railway, the comparison would, it was believed, be still more in favour of brick. Although the author preferred brick or stone, he by no means regarded iron as ineligible under all circumstances. In situations which did not yield suitable building materials, and where there were no cheap means of conveyance from a distance, the small relative mass of an iron viaduct would be a strong argument in its favour; for the whole weight of such a structure, including masonry foundations, would be less than one-fifth that of brick. This circumstance would also conduce to the selection of iron in cases of doubtful foundations.

ON SOME OF THE INTERNAL DISTURBING FORCES OF LOCOMOTIVE ENGINES.

By Mr. A. W. Makinson, M. Inst. C.E.

The author stated that, although the Permanent Way of railways had been much improved of late years, it was still a question for inquiry, which was proposed to be undertaken in the present Paper, whether, having regard to the safe transit of passengers at the high speeds now demanded on trunk lines, the locomotive engines were as free as possible from such internal disturbing forces as had a tendency to cause them to leave the rails.

In elucidation of the subject, the indicator diagrams taken from the cylinder of the "Great Britain" locomotive on the Great Western Railway in 1847-49-50 (*vide* Clark's *Railway Machinery*) at the velocities of 26, 35, and 52 miles per hour respectively, were selected for examination; and from these a series of diagrams was constructed, which exhibited graphically the different forces acting in a locomotive when in motion, numerical values being assigned to each of those forces.

The disturbing forces were divided into two classes—first, those which were generated by the revolving parts of the engine, as the crank, crank-pin, and half the weight of the connecting-rod; and secondly, those which were generated by the reciprocating masses, as the piston, piston-rod, cross-head, and half the weight of the connecting-rod, &c. As it was understood that, in the practice of the first locomotive engine makers, the proper counterbalance for the revolving appendages was now always applied, that class was not considered.

The nature and origin of the second class of forces were then examined in detail. It was observed that, if the circular path of the crank-pin around the axle was divided vertically by a straight line through its centre, then the crank arm would approximately coincide with this line, when in its positions both of greatest and of least velocity; and while the crank-pin moved through 180°, from its position of the greatest to that of the least velocity, the reciprocating appendages developed pressures in favour of the motion of the train, but when it moved from the position of the least to that of the greatest velocity, these appendages offered resistances to the motion of the train. Again, it was shown that, in general terms, at every velocity the pressures generated by the *vis inertia* of the reciprocating parts were the greatest at the end of the stroke, and vanished at or near to the mid stroke; the pressure during the second half of the forward stroke and the first half of the back stroke assisting the motion of the train, and during the second half of the back stroke and the first half of the forward stroke opposing the motion of the train.

It was only by adding the pressure thus developed by *vis inertia* to the simultaneous steam pressure, that the total efficient tractive power generated at any moment in either cylinder could be arrived at. The variation in amount of the tractive power, throughout one stroke of the piston, was thus seen to be much greater than when the steam pressures alone were considered. By adding together the amounts of tractive power simultaneously developed in the two cylinders of the ordinary engines, with cranks at right angles to each other, the total tractive force on the train at any point in one revolution of the driving-wheel, was arrived at; and the diagrams exhibited showed the great irregularity in amount of the total tractive force, operating to produce fore and aft motion in the engine and train. By comparing with each other the amounts of tractive force developed simultaneously in the two cylinders, the tendency to sinuous motion in the two-cylinder engine was shown; and exhibited graphically in one of the diagrams.

In conclusion, the author submitted that a single cylinder engine would be free from all sinuous motion: that at 26 miles an hour it would have about the same, and at higher speeds far less, fore and aft motion, than the ordinary two-cylinder engines; that by supplying the driver with the means of applying about as much power as was expended in putting the breaks on hard, a single-cylinder engine would have equal certainty of starting with the two-cylinder engine: and that the use of single-cylinder engines for passenger traffic would, by reducing the oscillation of the carriages, render railway travelling less unpleasant, and reduce the cost of locomotive power, and the expense of maintenance of way; whilst the dead weight of the engine, and the wear and tear of the several parts, would be diminished.

The appendix contained mathematical investigations and formulæ showing: 1st, the relation between the pressure on the piston, as observed by the indicator, and the equivalent pressure at the crank-pin; 2nd, the disturbing force generated by the unbalanced revolving masses; and 3rd, the pressures, referred to the crank-pin, generated by the *vis inertia* and varying velocity of the reciprocating parts of a locomotive in motion.

INSTITUTION OF ENGINEERS IN SCOTLAND.

THE PRESIDENT'S ADDRESS.

Gentlemen,—As is usual at the opening of the session, I shall very briefly address to you a few remarks; and, in the first place, I would simply refer to the many important and valuable papers that were read last session, and the discussions which followed thereon. The whole treated upon subjects of the most useful and practical description, and much important information was elicited by them, the volume forming one of the most complete we have yet had since the commencement of the Institution. Some of the subjects were in continuation of papers read during the previous session, to which I made reference when I formerly addressed you. As, however, the papers are to be specially considered by the members of the Institution, with the view of giving an expression of opinion on their merits, I will refrain from entering into detail upon them. I may here remark that I regret that our civil engineers should contribute so few papers to the Institution. The immense variety of constructions which are constantly going forward connected with railways, harbours, and canals, at home and abroad, furnish an ample supply of subjects for description and illustration; and I trust that in this and in future sessions, these, and the various points connected with the efficient and economical working and maintenance of such undertakings, may be brought forward more frequently and more prominently than they hitherto have been.

I purpose on the present occasion to give a short outline of, and make reference to some engineering works that have come under my observation since last I had the pleasure of addressing you, and put you in possession of some details connected therewith, which were kindly furnished me by the engineer in charge of the works. The first of these I shall notice is the Charing Cross Bridge, now in course of construction. It is intended to carry the South Eastern Railway across the Thames to their West-end terminus at Hungerford Market, and is to occupy the site of the present suspension bridge, which no doubt most of you have seen and admired as one of the late Mr. Brunel's early works.

The Thames at this particular place is about 1340ft. wide and was crossed by Mr. Brunel in three spans, the centre opening being 646ft. This foot-bridge is now being removed and a more substantial structure substituted to meet the requirements of the railway.

Mr. Hawkshaw, the engineer of the new bridge, divides the openings (on the Surrey side) of Brunel's bridge into spans of 154ft. each, by means of cylinders placed in pairs at three intervals; the two masonry piers of the suspension bridge, each 34ft. wide, being allowed to remain to form a portion of the new structure. Future generations may be somewhat per-

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pleased to account for these "breaks," and naturally say, why were not cylinders used there also? This simple reflection, however, would not have justified the expense of their removal; and, at all events, knowing the circumstances, we may safely exonerate the engineer from what might otherwise have appeared to be a piece of engineering eccentricity.

The principle of construction of the main girders of this bridge, though not absolutely new, has never, that I am aware of, been applied on such a large scale. I believe the same engineer is constructing one very similar at Londonderry, combining a carriage way on the top, which will shortly be opened for traffic.

I am aware it is not usual in an address of this kind to enter minutely into the details of any engineering work, however important; my duty being simply in a general way to notice such things, and express a hope that papers on similar works might come before the Institution in the usual and more convenient way. However, as we cannot always get English engineers to give us papers on their works when we wish it, I am tempted in this case to depart from the usual rule, and beg the attention of the meeting to a general description of this work.

The pair of cylinders forming the intermediate pier are distant from each other 49ft. and are somewhat bottle-shaped in appearance. The portion of each sunk below the bed of the river is 14ft. in diameter, cast in seven segments in lengths of 9ft., the flanges meeting and bolted together inside. The portion from the shoulder to the bottom of the main girder is 10ft. in diameter, cast in seven segments in 9ft. lengths, the flanges being also bolted inside, the thickness of the metal throughout being about 1¼in. In most cases these cylinders have been sunk 40ft. into the bed of the river, to prevent the possibility of any lateral motion, or of their bottoms being disturbed by any subsequent deepening of the river.

When completed, the lower portion up to the shoulder is filled with concrete, made with cement. Brickwork, set in Lias lime, is then used, the whole being surmounted by two semicircular blocks of granite 2ft. 6in. thick, cut to fit the cylinders, and when bedded projecting an inch or two above it, so as to keep the bottom of the malleable iron girder from resting on the casting. Both cylinders are joined together at the top by a cross girder, so as to guard against the barest possibility of any swinging taking place. Each cylinder is tested to the extent of 450 tons.

As already stated, these cylinders are 49ft. apart, and as the main girders rest directly upon them, it follows that that width represents the distance from centre to centre of each girder, and affords space for four lines of way. These main girders each weigh 190 tons, and when tested to 400 tons, showed a deflection of 1¼in.

The ends of the girders resting on the cylinders are composed of plates formed into rigid rectangular columns the same height as the girder, viz., 14ft., 5ft. on the face and 3ft. broad. The boxes or troughs forming the top and bottom of the girder are of that breadth, and of course spring from those ends. The upper one being inverted, its bottom forms the top of the girder, and, unlike the bottom of the lower trough, projects beyond the sides some 6in., and being in compression requires more metal in it; in the middle it consists of six plates—five of them ⅜in. thick, and one ⅞in. thick, breaking joint, and gradually diminishing towards the ends to two—one ⅞in., the other ⅜in. thick. The bottom of the lower trough is flush with the sides, and has five ⅜in. plates in the centre and two ⅜in. plates at the ends. The staging was made to admit of the simultaneous construction of these troughs; they are, with the above exception, precisely the same, each being 2ft. deep inside and 3ft. broad; each side is composed of two plates, ⅜in. thick, with two covering plates at pin holes, each 1in. thick; these pin holes occur at intervals of 11ft., and number fifteen in each span; four of the diagonals meet inside the troughs at those places; and two webs of the same thickness as the sides fastened to the bottom by angle irons 6 × 6 × 1, give additional bearing to the pins, and prevent the diagonals from sliding on them. The diameters of the pins vary with the strain, from 9in. at the ends to 5¼in. in the middle of the girder.

The diagonals at the ends are about 14ft. 6in. by 12in., and 3in. thick; in the middle, the breadth and thickness are about 6in. and 2in. respectively. Those in compression are forged to the required thickness, and strongly stiffened; those in tension are made up of two or three pieces of 1in. in thickness, according to strain, like the links of a suspension bridge. The cross lattice girders carrying the four lines of way, and projecting beyond the main girders, support a footway 7ft. wide on either side, and are suspended to the main girders by four strong angle irons immediately under each pin, and consequently occurring at 11ft. intervals. There is nothing very special in their construction to require further notice. The weight of each, I understand, is about 9 tons.

The bridge, when completed, will consist of six spans of 154ft. each, and three in the Middlesex side of 100ft. each; and the bridge is to be widened on that side to 171ft., so as to admit of seven lines of rails and platforms into the station. The radiating outside girders over these three openings remain the same in appearance as those of the rest of the bridge, to afford a continuous sky line; they have, however, very little work to do, and are consequently much more slender in construction; they rest on cylinders 8ft. in diameter. The railway is no longer carried on cross girders, longitudinal ones placed on cylinders 6ft. diameter, sunk at short intervals between the 8ft. outside ones being substituted. These girders are single web, and strongly made, their depth being limited to 5ft. for 100ft. span, to afford 25ft. headway above Trinity high-water mark, and are all under the level of the planking, so as not to interfere with the points and crossings of the lines of way to the platforms. The depth of the Thames at the site of the bridge, at low-water of spring tide is 11ft.

Rise of tide ..... 17ft. 6in.
Level of rails above Trinity high-water ..... 31ft. 0in.

The work is now more than three parts finished, and is perhaps the finest piece of work of the kind in the world. It is difficult to ascertain the cost of such a work. I believe, however, that £26 a ton for the wrought, and £16 10*s.* a ton for the cast iron, will not be far from the mark; 30*s.* a foot might also be taken as a pretty near approximation for sinking the cylinders.

I shall now proceed to lay before you some particulars of the Middle Level deluge—which caused so much excitement in the early part of this year—and the means resorted to by the engineers to stop it. Unless one has travelled in those districts in England known as the Fens, and forming large patches in the counties of Lincoln, Norfolk, Cambridge, and Huntingdon, he can scarcely realise the fact that thousands of families live and move, and quietly follow their farming operations, on a level only some two or three feet above low water mark. Every ploughman becomes an engineer deeply skilled in wattling, puddling, and embanking; and farmers show wonderful skill in the arrangement of their drains, which cut up and interlace their farms, until the water reaches the main drain at a convenient place, to be there pumped up and pounded, until the ebbing tide in the river, often many miles distant, allows it to pass to the sea. The early Dutch engineers, brought over by James I. of England, divided those immense tracts into levels or confederations, each getting peculiar privileges granted them by parliament, with power to levy rates on the acreage benefitted by their main drains and outfalls, for their construction and maintenance.

The Middle Level is one of those, consisting of 140,000 acres, extending nearly to Peterborough, and cut from off the sea-board by a belt of intermediate fens eight miles wide, under separate commissions, each maintaining, by their own taxation, independent drains and outfalls. The only thing common to all is the river Ouse, into which they all in that quarter drain, each commission subscribing to a general purse for the maintenance of its banks. This river rises in Bedfordshire, pursues a north-easterly and very tortuous course, receiving contributions from the Cam and other rivers as it passes through Cambridgeshire, and reaches the sea through the Norfolk estuary, a few miles below Lynn.

It is tidal for many miles into the interior, which during floods hinders the free passage of the water to the sea, and often prevents the gates of the inland main drains being opened for several days together.

The original outfall of the Middle Level waters into this river was, on account of the intermediate fens already mentioned, placed some fifteen miles from the sea, and was particularly subject to irregularity of action. The commissioners consulted the late Mr. James Walker, an engineer who was eminent for his skill in hydraulic works. (Since the preparation of the present remarks the rather sudden death of Mr. James Walker has been announced. This event must be deeply regretted by the entire profession on account of Mr. Walker's very high standing as a civil engineer; but it must be the more felt amongst us on account of his long connection with this locality, and from his being an honorary member of this Institution.) Mr. Walker advised the entire removal of the outfall sluice nine miles further down the river, and that parliamentary powers should be sought to make a main drain across the intermediate fens to it. This accordingly done, and, after encountering a severe parliamentary contest, the act was obtained.

The sluice consisted of three 20ft. openings, the sills being 6ft. below low water of spring tide; strong pointed gates opening outwards prevented the ingress of the tide so soon as the level of the water in the river exceeded that in the drain. The drain, which is perfectly straight, is on an average 130ft. wide; and its bottom, for the eight miles across this district, is 7ft. below low water. The level of the adjoining lands being only 3ft. 6in. above low-water for a length of six miles out of the eight, really gave good grounds for objecting to such a dangerous element being carried out on such a large scale through their very midst. But what they most dreaded was an accumulation of upland or fresh water in the drain during floods, more than could be discharged in the interval of low water, the pressure of which on banks, however carefully constructed originally, might, by negligence in maintenance, become unfit to meet all exigencies. On that ground they opposed the bill, and obtained protective clauses; but it does not seem to have occurred to them that any failure could ever take place in the outfall sluice, and it will be for the courts of law to decide whether those clauses do not altogether exclude the sufferers from any compensation whatever for the damage done by the sea. This is mentioned for

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two reasons—first, to point out that the land inundated was not the Middle Level at all, but the intermediate districts; and secondly, to be excused from giving, directly or otherwise, any opinion as to the sufficiency or insufficiency of the works which for eighteen years stood well, and almost convinced the most timid opponents that their former fears were groundless. Everybody admitted the drain and outfall sluices, from their magnitude and apparent efficiency, taken as a whole, to be a masterly piece of engineering.

To the Middle Level the boon was incalculable, and far more than realised the most sanguine expectations of its immense population. Pumping engines in many districts were abandoned, and land which was worthless during the old state of drainage soon brought upwards of £50 an acre.

On the 4th May, this year, Mr. Walker's grand sluice, without much previous sympton of decay, fell in pieces, as if rent by an earthquake; and the tidal waters of the Ouse rushed with indescribable fury up to the drain, until at the end of the eight miles they were checked by the barrier sluice on the frontier of the Middle Level district. The drain for this distance became a sort of creek; and had its bank been strong enough to have resisted until a dam could have been made across the mouth, no inundation to the adjoining country would have taken place. This state of things lasted for a week, several minor breaches in the banks being successfully stopped at every tide, until at last the west bank gave way at a point situate four miles up, and a tide 14ft. higher than the land rushed over the devoted country, then beaming with most luxuriant crops. The land being all of the same level, was not for a few tides covered to any depth, consequently the farmers were able to escape with their lives and also to secure their cattle. All attempts to stop the breach were perfectly futile, owing to the rush of water back to the drain again during low water. This altered state of things had also a wonderful effect on the dam the farmers were trying to put across the mouth. The twenty-four barges, varying in size from 30 to 80 tons each, which had been loaded and sunk in the yawning chasm to form a basin for some thousand sacks of clay to be built on at low water, were speedily separated and turned over; and nothing that could be sunk or thrown into the torrent would for a moment remain.

By the late Mr. Walker's recommendation, Mr. Hawkshaw visited the scene of disaster to see what could be done; and he at once gave orders to give up all attempts to stop the breach in the bank of the drain, which by this time was about 100 yards wide, because, if successful, the chances were that the opposite bank would give way, and do still greater damage to the lands on the other side. He also abandoned the idea of constructing the dam at the mouth, most of which had now been carried to sea, as, in addition to the sacks of clay and other make-shift material which were being thrown in, he wished to drive a few piles; so, taking advantage of a timber bridge of three openings across the drain near the mouth, he had all the pile engines that could be found in the neighbourhood placed on it, and set to work; nothing was to be put in until the piles were driven on either side of the bridge, and strongly braced together; the planking was then to be taken up, and the prepared material dashed in. Matters were so arranged that much progress was made in the course of two days with the driving of the piles; but during the progress of this work, up turns one of the huge 80-ton barges (which was supposed to have followed its companions out to sea), and dashing against the row of newly-driven piles, snapped them right through, and carried away the entire bridge as well as the piling engines and necessary appliances—the men only escaping with their lives. Two other occupation bridges shared a similar fate, but a bridge carrying a turnpike road resisted sufficiently to afford time to secure it. This was a most unfortunate accident, as great difficulty was experienced in getting a supply of pile engines in the neighbourhood.

Now was the time for the Dutch engineer, who, with Mr. Hawkshaw's consent, had been set down to try what could be done by sinking cradles, for such was the excitement generally throughout the country, and the imminent peril of the surrounding district, that Mr. Hawkshaw, seeing the time which must necessarily elapse before the destroyed land could be replaced, and a dam, such as he deemed necessary could be constructed, felt he would not be justified in offering any opposition; but, on the contrary, he heartily supported him. In the meantime, a few tidal and other observations established some facts that set all minds at ease, and went a great way in discountenancing the Dutch mode of procedure. First, the land inundated extended six miles along the west side of the drain, and was two miles broad at the widest place. On an average the water was 5 feet deep over all, being luckily confined to that area and depth by the existence of two roads which stood about 1ft. 6in. above that level, and surrounded it for many miles; and second, the tidal observations showed that the tide affected the level of the vast lake to an extent of only 6in.; so long, therefore, as the level of the roads held good, no further damage could arise by the free admission of the tide. The Dutchman, failing in the first attempt, was preparing a second cradle, when it became a very serious question whether he would not, by pounding up a certain quantity of water every successive layer of cradles he sunk (for to stop it in a few tides was not to be hoped for) gradually, but undoubtedly, raise the level of the water from 9ft., at which it stood until, in the course of time, it would approach the height of 18ft., which was the mark the same tide made at the dam. Where then would be the 1ft. 6in. we had to come and go on? His operation was, therefore, after due deliberation, stopped.

The difference of level of the water in the fen from that in the Ouse arose from the tidal current having to pass four miles through the drain before entering the inundated land; and from the extent of area inundated being no less than twelve square miles, it only affected the height of the water in the fen to the extent of 6in., as afterwards explained.

Before giving a description of Mr. Hawkshaw's dam, I may state some of the difficulties he had to contend with—Firstly, The high water in the inundated fen, as compared to the same water in the Ouse, was as 9ft. to 18ft., and the tide rose and fell in the fen 6in. Nothing approaching low water in the river could ever therefore be obtained in the drain. The only interval of repose, or what might be called slack water, was when the tide outside attained the height of 8ft. 6in. or level of the low water in the fen. Ten minutes time was sufficient to send a gentle current inwards, which increased in velocity every minute afterwards until high water; but the high water in the river being 9ft. higher than in the fen, no still water was again obtained until the tide had receeded in the river to that level; it then rushed out like a mill stream until the tide rose to 8ft. 6in. again. Secondly, The bed of the drain being 7ft. below low water mark, it followed that, at the time of slack water, when any work could be done at all, the depth of water in the drain was 15ft. 6in.; this was increased some 2ft. more, notwithstanding all efforts to maintain the bottom. The drain a short distance inside the site of the dam was ultimately deepened to 17ft. for a distance of 20 chains. Great caution was, therefore, necessary in any attempt to contract the sectional area.

The first thing to be done was to construct across the drain a strong stage 30ft. wide, resting on screw timber piling, which was projected into the current—the capstans on the piles being turned by ropes from the shore. Close piling on each side of this staging was then commenced, and continued from each shore until a clear space of 90ft. in the centre remained, it being considered imprudent to carry it further. This space was divided into twelve openings, by driving twin piles on each side of the stage opposite to each other, at 7ft. 6in. intervals. Great care was necessary in pitching those piles, and it could only be done during the short time of slack water. Each pile was 14in. square, and separated from its fellow by the first one having a thin piece fixed to its outer face, against which the second was driven, thus forming two grooves, 8½in. wide, for the panels, which were intended to be dropped into the openings, to slide in. Strong waling pieces of whole timber inside and out of each row at top, and as low as the water would admit of at the bottom, kept the whole in gauge, and the transverse timbers and iron bracings communicated any outward pressure through the dam from one row to the other, the outside of the dam being staid to the side of the drain by double timbers, 60ft. long, the ends abutting against piles backed by a mass of concrete. These struts were placed against the waling pieces at top and bottom, and stiffened by cross diagonals like a girder. The staging was left open at the top, to admit of material being tipped from the two lines of way, laid across the dam, and communicating with the prepared heaps of puddle and other material at convenient places up and down the drain on both sides. Two outside stages, one on either side of the dam, and supported by cantilevers from the twin piles, admitted of almost any quantity of tipping from barrows, to make good any scour which the soundings taken at every slack might indicate. The rush of water through the dam thus far completed, was, both on the flood and ebb tide truly alarming; the simple introduction of those piles and bottom walings causing a difference of head level of nearly 5 feet. In the midst of this roaring cataract, this framework and the dam stood without the slightest vibration being felt. It was daily visited by thousands who, though reserving to themselves the right of grumbling at what they did not understand, could not but admit it to be the only way of meeting the difficulty.

The greatest and most anxious care was now necessary to preserve the bottom of the drain from the scouring action of such a weight of water passing over it at the rate of 10ft. a second. Tons of broken stone were tipped from the outer stages and thrown overboard from barges, to form aprons on either side. But, except as a last resource, no stone was to be thrown into the centre of the dam, lest it should prevent it afterwards from being made perfectly water-tight. The long panels composed of timber 8in. thick, not framed, but merely built one above the other, and held together by three long bolts and heavy iron straps, made them quite rigid, and no difficulty was experienced in driving them. They were made with a sharp edge, and dollied down until their top was level with the bottom of the drain, or nearly so, and backed well outside with stone. Great quantities of puddle were tipped into the dam at every slack water; not with any hope of its remaining, but simply to feed the cancer—if I

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may so express it—and thereby allow less time for the dreadful current to act on the bottom. This was all the more necessary, for the piles on an average could only be driven 14ft. into the ground. All attempts to exceed that depth resulted in fracture. No doubt a bed of gravel existed at that depth, totally different in character from the coarse silt and alluvial deposit resting on it, and now so anxiously maintained.

The first attempt at closing the dam resulted in failure from the fracture of two of the twin or guage piles, which doubtless were injured in the vain attempt to get them deeper into the bottom. No blowing, however, occurred, and the panels when liberated were carried off. The greatest apprehension existed until the return of slack water, when the divers reported no damage, the lower panel, driven into the ground, prevented any cutting of the bottom. In consequence of the failure all the other panels down to low water were drawn, to allow free access to the tide, until the piles could be replaced. This was accordingly done, and a week elapsed in making good the damage and otherwise preparing to meet other contingencies, of which experience was daily pointing out the possibility. All was now ready; the panels were again swung in the gallows frames, ready to be dropped at slack water on the ebb. They were all lowered into their places in twenty minutes, material was then tipped in with great rapidity by the waggons, and the outsides weighted from the barrow stages. All was most successful; a little blowing took place where the stumps of the fractured piles interfered with the proper fitting of the panels in those places. However, by throwing a great quantity of hay, and piling a great quantity of clay bags on each side, it was checked until sufficient puddle was tipped into the centre. This was accomplished in twenty-four hours, and set so completely that not a drop escaped through. The tides no more went up the drain, but ebbed and flowed outside with a stillness which, when compared with the previous day, partook of that oppressive character experienced near a mill, or in the midst of going machinery, suddenly stopped. Syphons 3ft. 6in. in diameter were then placed over the dam to relieve the Middle Level from the surplus water that would not find its way to the Ouse through the old outfall, which for the present was again resorted to. Many thought they would not act. No good reason, however, could be urged against them, and all admitted that it was proper to make the experiment. These syphons have been finished and recently opened, and all found to do their work very well indeed. Their bottom level where they pass over the dam is 18ft. above low water, and the bottom of the mouths 6ft. under low water. In spring tides, high water rises 20ft. These operations have succeeded in relieving the Middle Level of water, and it will be a great boon to the whole of that district.

I trust that, while some of the members may consider the description and details of these important works uninteresting, others will be benefitted by them, and be led thereby to see the necessity of perseverance, so as to overcome unforseen difficulties that may be expected to arise during the progress of such works.

I have already referred to the desirability of more papers on civil engineering being brought before the Institution. It may be that the members who carry out the works which would form the subject of such papers, have not time for their preparation. But the younger members may take up any great work either in progress, or which has been completed, but not yet publicly described; and in doing so they need not limit themselves to works in this country. The rapid extension of railways on the Continent and in India is constantly giving rise to the necessity of constructing works of great magnitude; there are mountain ridges to be cut through, and ravines and rivers to be crossed of much greater magnitude than anything with us. In executing such works, the engineers in charge of them have the benefit of our experience. Few of us have an opportunity of inspecting these works in detail, either when in progress or by going over their plans. But I have no doubt that some of our members have the means of giving a professional account of many of these works, which, if brought before this Institution, would be most instructive and interesting. For instance, there are the Victoria Bridge at Montreal, the various railway bridges over the Rhine at Cologne, Mayence, and Strasburg, as well as others of similar construction across Indian rivers—all works of great difficulty and magnitude, and involving many novelties in construction which would each furnish a valuable subject for a paper. All these works are of wrought-iron, with arches of great span across wide and navigable rivers subject to great variations of level; and both in the general design and construction, they offer important lessons to the engineer. The Victoria bridge is a tubular one, and all the others are lattice bridges. Should the details of such works be brought before us, I would suggest that a careful comparison of the advantages, the difficulties, and the cost of the two systems of construction should be made, which I have little doubt would show that the lattice bridge is by far the better and the cheaper of the two. In these lattice bridges over the Rhine we have examples of the largest description of swing bridges yet constructed; and altogether, for elegance of design, excellence of workmanship, and economy in cost, I believe them to be unrivalled among recent railway structures. Those at Strasburg and Cologne are completed, and the one at Mayence is now in progress. The first consists of three central arches, each 184 ft. span, and of two side swinging arches 85 ft. span. The central piers are finished with handsome and effective Gothic spires, and the general appearance of the whole is most satisfactory. Its total cost was about £280,000. The bridge at Cologne is much larger, and embraces a railway and roadway alongside of each other, the cost being, I believe, somewhere about £500,000.

In carrying out the Swiss system of railways, ample opportunity has been afforded for the exercise of great engineering skill and ingenuity, of which full advantage has been taken. These must strike the eye of the professional tourist, even during the hasty run which is now taken by many among the Alps in summer; and there are two lines now in progress, which, when completed, will present works of a much more striking character than anything now in operation: these are the lines from Geneva to Turin by Mont Cenis, and from Martigny to Milan by the Simplon Pass. The first is now certain to be carried out, and its great and important feature will be the tunnel through Mont Cenis, which will be about eight miles long, and above 6000 ft. beneath the crest of the mountain. Of course, at such a depth intermediate shafts cannot be resorted to, so that the whole excavation must be carried on from either end. This very greatly increases the difficulties of the work; and these difficulties, coupled with the constructive skill necessary to be displayed in overcoming them, are such that the completion of the tunnel will be regarded as an epoch in rock excavation. The cost will be somewhat enormous, and would have been insurmountable, had it not been for the assistance given by the French and Italian governments.

The other line over the Simplon will have a higher summit level than that across Mont Cenis. Many points connected with its construction have not yet been determined, such as the level and length of tunnelling at the summit. When completed, it must embrace many works of striking magnitude and novelty, which will completely eclipse those of Napoleon's famous road, so long the admiration of Europe.

These railways will be of immense value to the countries they connect, more especially to Italy, which has suffered so much and so long from its commercial isolation from the rest of Europe; and I need not point out how valuable it will be to the profession, to have full and exact details of the most novel and striking of these works. In obtaining these, any one of our members can easily have the advantage of personal inspection of the works, should he find this necessary for an accurate description. Not so, however, with respect to those great works in India or America. At the same time many of these are made with English capital and by English engineers; and where this is the case there will be no difficulty in obtaining access to the plans. Some of the iron bridges have, indeed, been made in this country, and these now form the largest and most interesting of recent railway structures; so that the difficulty of obtaining the necessary details is not so great as may at first be supposed.

The railways in our American colonies, though invaluable to the districts through which they pass, have hitherto been unremunerative. This result has, to a large extent, been caused by inattention to economy in construction, and, as many believe, by disgraceful jobbing in financial matters. Notwithstanding these drawbacks, I have no doubt but the rapid progress of these colonies in material prosperity will soon furnish traffic to make the present lines profitable undertakings. By that time the colonies on the western shores will also be far advanced in commercial importance, so that we look forward at no distant date to an extension of the Grand Trunk of Canada across the Rocky Mountains to British Columbia. Such an undertaking will necessitate the construction of works of magnitude equal to, if not greater than those already completed. Its effect on the development of the resources of the vast territory which it will traverse, will be invaluable. The result, therefore, will be equally great in a professional and national point of view, and may claim the attention alike of the engineer and the statesman.

The great question of cotton supply renders the rapid extension of railway transit in India a matter of the most pressing and immediate importance. Invaluable time has already been lost in endless discussion of detail by parties who were entirely unfitted for such work; and it is to be hoped that now, when a beginning has been made, Indian railways will be pressed on with all practicable speed. It has been a matter of bitter reproach against England by Burke, and by all who have followed him in challenging our Indian policy, that we have done so much in conquering the natives and in enriching ourselves, and so little in opening out the material resources of that magnificent country. Our greatest boast has been our advancement in the arts, in mechanics, and engineering, and more especially in all processes connected with improvements of land transit; yet, during the century of our sway in India, we have allowed the great works of artificial navigation made by former engineers to fall into decay, and have been contented to carry on intercourse in one of the richest and most populous countries in the world by bullock tracks, like those described by Livingstone as being used by the African savages among whom he travelled.

We have now entered upon a different policy. Trunk roads and trunk railways have been traced out, and partially constructed between the capitals of the various Indian provinces. We have commenced to improve the river navigation, and to place steamers on all the larger streams. The old tanks and

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canals for irrigation have been repaired, improved, and greatly extended; and if this course be persevered in, we may expect to see the whole country opened up in a short time by works which will make internal transit there as cheap and efficient as it is with us, and which will form the most striking monument yet raised to the power and magnificence of Great Britain. I need not point out what a large field of engineering employment the construction of these works will open up, nor the necessity of smoothing away the difficulties which their construction will give rise to, by a full discussion of them at institutions such as this.

I alluded, in my address of last year, to the prospects of the Great International Exhibition, and to the part which we expected the industry of the west of Scotland to occupy, and I am glad to be able to congratulate the members that our expectations in these respects have been fully realised.

The Exhibition, almost in every respect, exceeded that of 1851 as regards number, variety, and importance of the articles brought forward; and Great Britain, on the whole, has had reason to be proud of the position she has occupied in the grand industrial tournament to which she had challenged the world. In the production of metals, chemicals, glass, and earthenware, and of all ordinary woven fabrics, we have undoubtedly distanced all competitors, with some very few exceptions.

In the case of machinery, the department more peculiarly interesting to engineers, it may be said without exaggeration that we have been first. There certainly is no comparison between our locomotives, our marine and land engines, our spinning and weaving machinery, our sugar-mills, and our tool-making machinery and those exhibited by our rivals; and it must have given great saisfaction to all of us to see the honourable position occupied by many of our own members who are exhibitors in these classes.

Amongst the few exceptions I have referred to, I may mention railway carriages and their fittings, cast-steel forgings, and some of the unusual forms of rolled iron. It has long been matter of common remark, that the carriages of foreign railways were better and more comfortable than those of a similar class with us. This may be partly explained by the large proportion of old and badly-constructed stock still kept up by many companies in this country. But even allowing this, I am afraid that it must be admitted that foreign stock of railways is fully superior to our own; and there can be no doubt that the best foreign carriages exhibited were fully equal, if not superior to those of English make. Many reasons have been assigned for this, but they may all be resolved into the simple fact that our foreign rivals have paid more attention than we have done to the proportions and quality of the fittings and to the excellence of the workmanship in every minute particular. It is impossible to over-estimate the importance of attention to these points, not only as regards the comfort of passengers, but also as regards the question of economical working. Repairs and renewal of rolling stock form a very large portion of the working expenses of a railway; and to use stock after it becomes ripe for renewal is not only severe upon itself, but is equally injurious to the permaneut way. The rail and the wheel are, in the words of Stephenson, "man and wife," and you cannot injure or depreciate the one, without doing corresponding damage to the other. This great truth is now fully recognized in railway management, and is shown by the increased attention which is being paid to the improvement of rolling stock and of the permanent way; and I hope that such attention, coupled with the natural decay of old and objectionable rolling stock and its renewal, will soon enable us to surpass all continental railways in these all-important matters.

It must have struck every one that foreign carriage fittings in iron, more especially those from France, were also fully equal to ours. They were certainly lighter and very well made; and I was surprised at being informed that they were actually cheaper than with us, being only on an average 2½*d.* per lb. This is a somewhat astonishing result, if we consider that the raw material is 25 to 40 per cent. dearer in France than in Britain. We have almost all the materials for iron-making—the ore, the coal, and the lime, lying in close juxtaposition, so that with us the cost of raw material is very small indeed. But in France they are widely separated, and the extra cost of carriage, compared to what it is with us, raises the price of pig-iron from 60*s.* to 90*s.*, and of bar-iron from 130*s.* to 170*s.* per ton. It is very much to the credit of the French manufacturers that they can, in the face of this great difference against them, produce iron work of first-class quality as cheaply as in Britain.

They also produce angle iron, T-iron, and I-iron of extra sizes for smaller extra charges than those made by our makers; and they have carried the manufacture of these extra sizes and forms much farther than we have done; and I understand it is the case that many of these sizes and forms must be ordered by our Glasgow iron merchants from French and Belgian makers, and the prices are so low that L-beams, 12in. deep, cost only £12 10*s.*, and when 2ft. deep, £20 per ton. There is no doubt that the advantages we possess for ordinary sizes and qualities, with proper skill and attention, ought to be carried into every branch of the manufacture. Were this done our foreign trade would be greatly extended, and the use of iron would be adopted to a larger extent in many kinds of industry.

A good deal of the uncertainty attendant on the introduction of iron-making arises from the obscurity which still surrounds many of the chemical changes that take place in its various stages. This obscurity can only be removed by accurate experiments on a large scale. These could easily be conducted by many of our members who are connected with the manufacture; and such a series of experiments, besides being of great value to the makers, would furnish the subject of many excellent papers, which I hope to see brought before the Institution.

In concluding these remarks, I have much pleasure in being able to congratulate the members on the increased and increasing prosperity of the Institution in every respect. Although, we however, had a considerable increase in the number of members last Session, we must not show any laxity in increasing the number with suitable members still more, so as to keep up our funds, which naturally will fall off, owing to the entry-money and yearly subscriptions having been recently reduced; and this is the more necessary as we will require to draw pretty heavily on these funds in the establishment of such a library as will be worthy of the Institution.

I refer with much satisfaction to the pleasant and agreeable meeting our last conversazione afforded the members and their friends; and much praise is due to our Secretary and the members of committee who were intrusted with the arrangements. I trusted that the Institution may see proper to have a similar meeting at the close of the present Session, as I think such meetings have a tendency to create good feeling and harmony amongst the members of the Institution.

On the motion of Mr. R. Bruce Bell, a hearty vote of thanks was awarded to the President for his very interesting address.

Mr. Walter Macfarlane begged permission to offer a few remarks, suggested by the President's address. The member must feel deeply indebted to the President for bringing so fully before them the railway bridge and terminus at Hungerford, which was to connect the railways on both sides of the Thames at Charing Cross. There was a probability of their soon seeing a scheme launched in Glasgow of a kindred sort—a general terminus in this city to connect all their railways. He could not but express his regret at the very disgraceful state in which Glasgow stood in regard to her railway termini; and it must be patent to them all that a large amount of money was unnecessarily spent from this cause. It had generally been held that the great obstacle to the success of a general terminus was its expense, which he did not think should be the case in such a city. Seeing that London, with the view of centralizing her various railway depots, had carried out such a scheme, he thought there would be no difficulty in this, the second city in the empire, following the example, and taking a position more creditable than it now occupied. The President's remarks were most suggestive, and a meeting such as the present was most valuable, as it gave a good opportunity for bringing their engineering opiuions to bear upon a scheme before it was finally committed. Glasgow should look upon this matter in a broad aspect of view, and see the necessity for having railway accommodation commensurate with the increase and extent of the city. The Central Railway Terminus to which he had referred was very much akin to the Hungerford Market and Bridge scheme. Hungerford Market had only been established thirty years, and yet it was being removed at enormous expense; and if one or two railways at Loudon could do this, he should be disappointed if Glasgow were not soon in a similar position.

The President endorsed all that Mr. Macfarlane had said. He was of opinion that if it was found necessary to join the London railways, much more was that the case in Glasgow, for it would connect the leading lines in the west and south of Scotland with those of the north and east of Scotland. He knew a good deal about the scheme referred to, having been consulted in reference to it. He had seen Mr. Hemans, the engineer, who had got ready the plans and a very fine model, which was exhibited in one of the booths at the west-end of Bothwell-street. He believed the chief difficulty was the want of money, but partly also the absence of co-operation on the part of the railway companies. However, he had no doubt that the scheme would come up soon, although it would not be proceeded with in the present session of parliament.

ON THE UTILIZATION OF PEAT, WITH REFERENCE MORE PARTICULARLY TO THE MANUFACTURE OF HYDRO-CARBON OILS.

By B. H. Paul, Ph.D.

(*Continued from page* 17.)

The amount of tar obtainable from the peat is of considerable importance. The amount obtained by Mr. Sullivan from Irish peat, in no instance amounting to 5 per cent., and on the average 2·5 per cent., is far to small to admit of the peat being worked profitably.

The influenced of an increased yield of tar on the cost of the products, will be very clearly apparent from Table II., in which the quantity of peat worked per week is throughout taken as 100 tons, and the yield of tar varying from 1 to 10 per cent.

It will be seen that a yield of 3 per cent. tar from the peat would, at the cost of peat and labour assumed in this table, make the cost of the tar £6 6*s.* 8*d.* per ton, and that if the refined product from the ton of tar amounted to only 100 gallons, the cost of the oil would be 1*s.* 10*d.* per gallon, or far too much to admit of profitable working.

To determine this point, therefore, with certainty, an experimental distillation of the Lews peat—air dried—was made in a close retort, it gave the following results:—

Tar			9·855
Charcoal	Carbon	30·25	31·500
	Ash	1·25	
Water			37·875
Gas			21·549
			100·000

which were subsequently confirmed by trials on a larger scale.

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TABLE II

Per centage yield of tar from peat.	Quantity of peat worked per week.	Tar produced. Tons.	Tar produced. Gallons.	Refined oil and paraffin.	Cost of Tar made. Peat 2s. per ton.	Cost of Tar made. Labour.	Cost of Tar made. Equal	Cost of tar per ton. £	s.	d.	Cost of tar equivalent to 1 gallon refined products; these being 100 gallons = 1 ton tar. s.	d.	Cost of refining per gal. d.	Cost of refined oil per gallon. s.	d.
				gals.	£	£	£								
1	100	1	233	107	10	10	20	20	0	0	4	0	6	4	6
2	100	2	460	214	10	10	20	10	0	0	2	0	6	2	6
3	100	3	699	321	10	10	20	6	6	8	1	4	6	1	10
4	100	4	932	428	10	10	20	5	0	0	1	0	6	1	6
5	100	5	1165	535	10	10	20	4	0	0	0	10	6	1	4
6	100	6	1398	642	10	10	20	3	6	8	0	8	6	1	2
7	100	7	1631	749	10	10	20	2	17	2	0	7	6	1	1
8	100	8	1864	856	10	10	20	2	10	0	0	6	6	1	0
9	100	9	2097	963	10	10	20	2	4	6	0	5½	6	0	11½
10	100	10	2336	1070	10	10	20	2	0	0	0	5	6	0	11

The tar thus obtained, as I have already mentioned, yielded 42 per cent. by weight of refined oil and paraffin; so that the 100 tons of peat, as compared with the average of Irish peat, would yield:—

	Tons.	Tar. galls.	Crude Oil. galls.	Refined Oil. galls.	Creosote. galls.
Lews peat	100 ...	2,097 =	1,629 =	999 +	630
Irish peat	100 ...	479 =	696 =	357 +	343

In this case, taking the cost of the peat as before at 2s. per ton, the quantity of Lews peat, equivalent to one gallon of refined products, would cost only 2½*d.* instead of 7*d.*, as in the case of the Irish peat; and adding in each case 1*s.* per gallon as the cost of manufacture, the refined oil from Lews peat would cost 1*s.* 2½*d.* per gallon, while that from Irish peat would cost 1*s.* 7*d.* per gallon.

In the above table the cost of manufacture is taken from the results of actual experience; but the per centage of tar, which I have just referred to as obtainable from the Lews peat, was obtained by distilling it in a close retort. This is not the plan that has been adopted practically, and it is possible that in distilling peat with close retorts, the cost of manufacture would be increased beyond what has been quoted in the above table, by the necessity of using peat for fuel; if, for instance, it should be found that the charcoal obtained from one operation was insufficient for the distillation of a subsequent charge of peat. If that were the case, the working with close retorts would involve an additional expense for fuel. The peat thus consumed as fuel would, in reality reduce the actual per centage of tar obtained from the peat consumed, and if one-third the weight of the peat were consumed as fuel, the per centage of tar obtained would be, in fact, not 9·8 per cent., but only something like 6 per cent.

At the outset of the inquiry into the working of the Lews peat, it therefore became an important question whether it would not be more economical to work with kilns, as was done at the Irish Works; whether the large yield of tar obtained with retorts was not to some extent only apparent; and whether a smaller yield of tar. obtained by means of kilns, might be more advantageous by reason of their smaller original cost, and of their requiring a smaller expense for labour and fuel in working than retorts.

The small amount of tar obtained from the peat at at the Irish works was, no doubt, partly a consequence of the inferior character of the peat; but a little consideration of the circumstances under which the peat was distilled will suffice to show that it was mainly attributable to the use of the blast employed in maintaining the combustion, in the same manner that it is employed in an iron-smelting furnace. Some results are indeed mentioned by Mr. Reece, and quoted by Sir Robert Kane in his redort, which clearly suggest this view. Thus. for instance, Mr. Reece states that, in the experiments made in Antrim, in 1850, with a kiln 3ft. diameter and 15ft. deep:—

When the quantity of peat distilled during 24 hours was 1½ ton, the produce of tar was 70lbs. per ton = 3·1 per cent.

When the quantity of peat distilled during 24 hours was 2 tons, the produce of tar was 40lbs. per ton = 1·8 per cent.

When the quantity of peat distilled during 24 hours was 3 tons, the produce of tar was 22lbs. per ton = 0·91 per cent.

When the quantity of peat distilled during 24 hours was 9 tons, the produce of tar was only 2lbs. per ton.

In the experiment by Dr. Hodges, which gave 4·44 per cent. of tar, the distillation of two tons of peat occupied three days, and the blowing machine employed in that experiment is described as having been "very inefficient," and furnishing only "an intermittent blast of no great power." The same fact is pointed out in Sir Robert Kane's report, as having been observed in the course of the investigation made at the Museum of Irish Industry by Mr. Snllivan. When much air was blow through through the apparatus, scarcely any condensible products were obtained; when little air was blown through, the distillation was very slow and incomplete.

This result of a very small yield of tar when a strong blast was used appears to be clearly attributable to the peat having been burnt in the kiln instead of having been distilled; and this view of the matter led me to the conclusion that it would be advantageous to dispense with the blast altogethor, as being not only very expensive, but also useless and unsuitable for the production of tar. It appeared to me that a more appropriate means of maintaining the combustion of the charcoal at the lower part of the kiln, so as to produce the requisite heat for distilling the peat at the upper part, would be to have a fire-grate at the bottom of the kiln, and to establish a draught through the fire by exhaustion from the upper end of the kiln. It appeared to me, moreover, that by this means the escape of the tar vapour from the kilns would be facilitated in a much greater degree than by the blast driven into the kilns at the bottom.

This opinion was supported by the result of some experiments made with a small kiln, constructed in this manner, which was worked for some time in Lews. In this kiln the draught was produced by means of a chimney placed at the further end of the condenser, and the yield of tar obtained with this experimental kiln amounted to 5 per cent.

The tar thus produced differed somewhat from that obtained by distillation in close retorts chiefly in respect to the relative proportions of light and heavy oils and paraffin, as will be seen by the following results of the analyses of these two tars:—

Density.	Retort Tar.	Kiln Tar.
Light oil (0·820—0·830)	18·678 ...	5·147
Heavy oil 0·870	20·165 ...	30·885
Paraffin	3·318 ...	5·135
Creosote	30·459 ...	47·068
Charcoal gas and waste	27·380 ...	11·765
	100·000 ...	100·000

This difference might, however, be owing to defective condensation of the more volatile portions of the tar vapour, as the arrangements connected with the experimental kiln were in many respects very imperfect. Otherwise the tar was as easily worked as that obtained with close retorts and the general result of the trials made with this kiln was so far favourable to this mode of working, that when arrangements were made for erecting works to make six tons of tar a week, it was determined to construct a range of kilns of this description, in preference to putting up retorts; at the same time it was hoped that with a more efficient arrangement for condensing the tar vapour, a larger yield of tar than 5 per cent. might be obtained.

These preliminary matters having been satisfactorily disposed of, preparations for erecting works were commenced in the early part of 1859. The tar kilns were cylindrical baick chambers 5ft. diameter and 12ft. high, with a fire-grate of about 2ft. area at the lower end, and a hopper with a lid at the top for introducing the peat. Ten of these kilns were constructed side by side in a block of brickwork. From the side of each kiln passed a pipe 12in. diameter, which was connected with a main 3ft. diameter, extending round the whole range of kilns, and into which the tar vapour from the kilns was discharged. From this main the vapour passed into a series of pipes 12in. diameter, arranged on cisterns much in the same manner as the condensers of gasworks, but with the difference that there was no water joint. After passing through this condenser the uncondensed gases were discharged into a brick chamber with numerous partition walls, and thence into a large flue running for about fifty yards up the side of a hill on the top of which was placed a chimney 30ft. high.

A tramroad ran along the top of the kilns, communicating with the tramroads diverging through the moor, for bringing up the supplies of peat; and, as the peat burnt away at the fire-grates, a fresh quantity was introduced at the upper ends of the kilns. This charging required to be repeated every two or three hours. The product collecting in the condenser cisterns was a thick creamy mixture of tar and water of a pale sulphur colour, from which the tar was separated by heating it in a large boiler and skimming the tar off the surface.

With this arrangement work was commenced about the end of August, 1860; but, owing to the wet state of the brickwork, and to a temporary difficulty with the workpeople, it was not until the early part of October that the kilns were got into regular working order. From that time the work was carried on without any considerable interruption until the end of February, 1861. The results obtained during this period were far from being satisfactory. In the first place, the tar made did not amount to more than 3 per cent. of the peat consumed; and, in the second place, the quantity of peat worked did not amount to more than 50 tons a week on the average.

The expenses of labour in working the kilns being very nearly the same, whether the quantity of peat worked was large or small, the slow rate of working necessarily increased the cost of the products, and this circumstance has an influence as important in this respect as the yield of tar, as will be apparent from the comparison given in the annexed table.

Moreover, the rate of working was subject to wide variation. This latter circumstance, which was productive of much inconvenience, appeared to be mainly determined by the state of the wind. During calm weather the quantity of peat worked was not much more than half that worked when there was a fresh breeze. With a dead calm the action of the kilns would sometimes be entirely stopped, and during gales, which were of very frequent occurrence, it was impossible to continue working. The most troublesome effect of these two extreme conditions was the production of a back draught from the chimney, though the condenser, towards the kilns, by means of which air became mixed with the

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Per centage yield of tar from peat.	Quantity of peat worked per week.	Tar produced.		Refined oils and Paraffin.	Peat 2s. per ton. Labour.	Cost of Tar per ton.	Cost of Tar equivalent to 1 gallon of Refined Oil.	Cost of Refining per gallon.	Cost of Refining Oil per gallon.
	Tons.	Tons.	Gallons.	Gallons.	£ £ £	£ s. d.	£ s. d.	£ s. d.	£ s. d.
5	50	2½	583	268	5 + 10 = 15	6 0 0	0 1 2½	0 0 6	0 1 8½
5	120	6	1398	642	12 + 10 = 22	3 13 6	0 0 9	0 0 6	1 3 0
5	200	10	2330	1070	20 + 10 = 30	3 0 0	0 0 7¼	0 0 6	0 1 1¼

vapours and combustible gases; and, when this admixture reached a certain limit, explosions sometimes took place, which were both inconvenient and dangerous.

The slow rate of working which, as shown by the following table, rendered the charge for labour proportionately much greater, was, to a great extent, a consequence of the feeble and irregular draught produced by the chimney. In addition to this, the tar vapour did not appear to escape from the kilns through the 12in. discharge pipes with sufficient ease. The consequence was that much tar was condensed among the cold peat at the top of the kiln, and this tar, melting afterwards, ran down to the fire, and was there more or less burnt and destroyed. Hence the small yield of tar.

Since the feeble draught of the chimney was the chief cause of these unsatisfactory results, and since that was itself a consequence of the extreme refrigeration of the vapour and gas during its passage through the condenser, the defective draught might have been remedied by maintaing a fire at the base of the chimney, so as to heat the cold uncondensed gas escaping from the condenser, where the tar had been deposited, sufficiently to produce a steady draught; but, since the gas escaping into the chimney was highly combustible, this would have been too hazardous a plan to adopt, inasmuch as the weather was frequently so boisterous that it was with difficulty that work could be carried on at all out of doors; and, as the kilns were worked continuously, there would heve been much inconvenience attending this mode of working during the very long nights of winter.

Under these circumstances, it appeared to me desirable te have recourse to some mechanical means of producing a draught, that would be constant in its action, easily under control, and which would admit of the gases discharged from the condenser being burnt with safety by the introduction of a water joint between the condenser and the place where they were burnt. A further reason for adopting an arrangement of this kind was the presence, in the uncondensible gases escaping from the condenser, of a large quantity of tar, which was suspended in a kind of vesicular position, and was not separable by any amount of cooling that was practically applicable. The smell produced by the escape of this tarry gas into the air was exceedingly offensive for miles around, and for this reason, as well as for the sake of using the gas as fuel, it was determined to burn it. Moreover, though the separation of this suspended tar could not be effected by cooling the gas, it was easily separated by mechanical means, such as passing the gas over loose bunches of heather. This plan has been adopted while working with the chimney draught, and, so far as the separation of the tar was concerned, it succeeded perfectly. A long brick chamber was connected with the flue leading to the chimney, so that the gases were made to pass along it in a zigzag course by coming in contact with bunches of heather tied to cords and suspended from the roof of the chamber. The effect of this arrangement in separating the suspended tar was instantly recognisable, the gases escaping from the chimney being almost free from tar. But the draught of the chimney gradually decreased, and at the end of two or three weeks had ceased altogether. On opening the chamber it was found to be entirely choked with tar that had been deposited upon the bunches of heather like drifts of snow. This circumstance suggested the introduction of several such chambers into the condenser, and it was also expected that the passage of the vapour and uncondensible gas through water would have a similar influence in separating this tar. But to overcome the resistance that would thus be offered to the passage of the vapour and gas from the kilns, it was necessary to have a very powerful draught, and, after considering the various means employed at gasworks for exhausting, I decided upon trying the effect of a revolving fan. A very excellent form of fan of great power was suggested for this purpose by Dr. Rankine, but, as time was a considerable object, one of the ready-made fans, manufactured under Schiele's patent, by the North Moor Foundry Company, was chosen for the trial.

In order to get a satisfactory result in working the kilns it was necessary to work up at least seventy tons of peat a week, and to obtain fully 5 per cent. of tar. Assuming that by the application of a fan this result was obtained, then the quantity of uncondensible gas passing away from the kilns might be taken as consisting essentially of the carbonic oxide produced by the combustion of the coke or charcoal yielded by that quantity of peat, plus the oxygen of the air required for its combustion. Taking the peat to yield 25 per cent. of charcoal, and the quantity worked as ten tons daily, there would be some 4lb. of carbon to be converted into carbonic oxide per minute in the kilns. This quantity would require rather more than 300 cubic feet of air, which, by conversion into carbonic oxide, would become about 360 cubic feet, and, at the temperature it entered the fan, might amount to 500 cubic feet. This, then, fixed the minimum capability of the fan to passing 500 cubic feet of gas per minute, even if the quantity of peat worked did not exceed seventy tons a week. But this rate of working was considered too small, and I was desirous of increasing it to double or three times as much, and with that object decided upon employing a fan capable of passing 2000 cubic feet of gas per minute, so as to leave an ample margin for increasing the rate of working, and to allow for any augmentation of the voluume of gas not calculated for.

The fan chosen for this purpose was a 30in. Schiele's fan, driven at a rate of 1600 revolutions by an 8in. engine, which worked some pumps and a winding drum, by which the peat trucks were drawn up an incline to the kilns. This fan was found to produce a powerful steady draught through 7in. of water, without raising the combustion at the fire-grate of the kilns to a higher degree than was desirable. The area of the discharge pipes from the kilns having been doubled, the vapour was rapidly drawn from the kilns, and the tar was much more completely separated by passing the vapour several times through water and through four chambers filled with layers of heather. The mechanical action of the fan was also found to be very efficacious in separating the suspended tar, which appeared to be churned out of the gas by the fan.

The current of gas discharged from the fan was highly combustible, and burnt freely at the ordinary temperature. In order to prevent its causing an unpleasant smell, and to render it available as a source of heat for generating steam, distilling tar, evaporating liquors, or drying, it was led through an underground tunnel to a furnace, where it burnt with a flame from 6ft. to 10ft. high, 6ft. long, and 6in. thick.

In working with the chimney draught it had become apparent that the quantity of charcoal produced from the peat, as it passed from the top of the kiln to the fire-grate, was very much greater than was requisite for distilling off the tar from the subsequent charge of peat, and consequently there was considerable waste of time, besides other obvious disadvantages, involved in the combustion of this surplus fuel. To remove this obstacle to the increase of the quantity of peat worked in the kilns, an arched opening was made in each kiln, just above the fire-grate, and fitted with a door, through which the charred peat could be drawn out at intervals, in such quantity as to leave only just enough to serve as fuel for distilling the peat. This plan could not be regularly carried out during the last winter, on account of the danger of opening the doors of the kilns during high winds while the front of the kilns was unprotected by sheds. It was nevertheless found that by drawing out the surplus charcoal the quantity of peat worked was very much increased, and a very much more considerable advantage would have been gained in this respect if the removal of the charcoal could have been effected independently of the weather.

In illustration of the effect of these improved arrangements it may be mentioned that the quantity of peat worked was considerably greater than when working with the chimney draught, being in all cases upwards of 70 tons a week, and while the weather was favourable for drawing the surplus charcoal, upwards of 100 tons a week. The yield of tar was also increased to the extent of 7·5 per cent. of the peat worked, and was on the average as much as 7 per cent. The number of men required for working the kilns was also much smaller than was the case while working with the chimney draught. These results were in every respect very much more favourable than what had been anticipated at the outset, inasmuch as the cost of the tar, instead of being £5 per ton, was under £3 per ton, while on the other hand the quantity made per week, instead of being only 6 tons, was upwards of 7 tons, and was also in a fair way of being increased.

One of the products obtained from the peat tar was a burning oil of excellent quality, similar to paraffin oil and the oil obtained from American petroleum. It was sold last winter in Glasgow, under the name of lignole, and was examined by Dr. Anderson, who expressed his opinion that it would compare favourably with the best varieties of mineral oils obtained from coal. The production of this oil is an important feature of novelty in the working of peat.

The heavier oil obtained from the tar would burn very well, but it requires a different form of lamp from that generally employed now for the hydro-carbon or so-called paraffin oils. When mixed with fat oils it forms a good lubricator. Some samples of this oil, mixed in proportions suitable for the spindles of cotton machinery, were examined by Dr. Rankine, of Glasgow, who reported on them as follows. The standard of comparison was sperm oil:—

"The following table shows the results, the oils being arranged in the order of their friction-reducing powers, as shown by the number of revolutions made by the spindle:—

	Relative lubricating power.	Number of Revolutions.
Oil No. 5	101	416
Sperm oil	100	411¾
Oil No. 3	98	404
Oil No. 2	97	401¼
Oil No. 1	85	349½

"The conclusions are that the oil No. 5 is somewhat superior to sperm oil as a lubricant, and Nos. 3, 2, and 1, somewhat inferior; but in the case of Nos. 3 and 2 the inferiority is only slight."

"I have not yet had an opportunity of testing by direct experiment the lubricating effects of these oils, or of compounds containing them, on the bearings of large and heavy machinery. The principal difference required in unguents for different kinds of machinery depends on the intensity of the pressure at the bearings;

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the more intense pressures requiring thicker or more viscid unguents, that they may resist the tendency of the pressure to force them out. Additional thickness is given to an unguent, when required, by dissolving a sufficient quantity of solid greasy matter in the oil; and from previous observation of the properties of unguents containing oils analagous in their chemical character to those with which I have been furnished from the Lews Chemical Works, I am satisfied that the latter oils may easily be thickened in the same manner, so as to adapt them to any intensity of pressure at the bearings to which they may be applied."

The apparatus by means of which these oils was tested, as regards their application to cotton machinery, consisted of a cotton spindle, supported in a vertical position upon a pivot lubricated with the oil to be tested, and carrying a fly or revolving disc. This spindle is set in motion by a constant weight, descending through a constant height, and allowed to revolve freely until it stops of itself, the whole number of revolutions made before stopping being counted by the aid of suitable mechanism. The greater that number of revolutions, the more perfect is the lubrication produced by the oil; and, inasmuch as the bearing at which the friction is tested, is that of an actual cotton spindle, the results of the experiments give a peculiarly satisfactory test of the qualities of the oils for lubricating these bearings, and bearings of light machinery in general.

Having already referred to the Irish Peat Company's works, and to the results obtained there, I would now wish briefly to point what appears to have been the circumstances which contributed to the signal failure of that undertaking. Table III. contains a comparative statementof the results anticipated from the working of Irish peat, and of the results actually obtained.

TABLE III.

	1		2		3		4		5		6		7	
	Anticipated results from the working of Irish Peat, as set forth in the Company's Prospectus, on the authority of Mr. Reece, 1851.	Value.	Sir Robert Kane's Report 1851.	Value.	Working Results with Irish Peat, as given in Mr. Sullivan's Report to the Directors of the Irish Peat Company, 1855.	Value.	Retort Tar from Lews Peat, 1858.	Value.	Kiln Tar from Lews Peat, 1858.	Value.	Working Trial of 1 ton Kiln Tar from Lews Peat, 1858.	Value.	Working Result from Lews Peat since the Fan was used, 1861-62.	Value.
		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.		£ s. d.
Quantity of peat worked 100 tons.		10 0 0	100 tons.	10 0 0	100 tons.	20 0 3	100 tons.	10 0 0	100 tons	10 0 0	100 tons	10 0 0	100 tons	10 0 0
Sulphate of ammonia ..... 20 cwt.		12 0 0	20 cwt.	12 0 0	3 cwt.	1 16 0								
Acetate of lime ..... 14 cwt.		9 16 0	4 cwt.	2 16 0	—									
Wood naphtha, 5s. per gal. 52 gals.		13 0 0	52 gals.	13 0 0	10 gals.	2 10 0								
Crude oil, 1s. „ „ 300 gals.		15 0 0	300 gals.	15 0 0	—									
					300 lbs.									
Paraffin, 1s. per lb. ..... 300 lbs.		15 0 0	300 lbs.	15 0 0	150 gals.	15 0 0	999 gals.	99 18 0	535 gals.	53 10 0	500 gals.	50 0 0	749 gals.	74 18 0
Refined oil, 2s. per gal.						15 0 0	330 gals.		560 gals.					
Creosote														
Total value of products		64 16 0		57 16 0		34 6 0		99 18 0		53 10 0		50 0 0		74 18 0
Cost of material & manufacture		32 2 0		32 2 0		34 3 4		Cost of working not ascertain'd		37 10 0		37 10 0		38 14 6
Balance		32 14 0		25 14 0		0 2 8				16 0 0		12 10 0		36 3 6
Value of oils and paraffin		30 0 0		30 0 0		30 0 0				53 10 0		50 0 0		74 18 0
Cost of material and manufacture		32 2 0		32 2 0		34 3 4				37 10 0		37 10 0		38 14 6
Balance		2 2 0		2 2 0		4 3 4				16 0 0		12 10 0		36 3 6

Together with these results are given, also, comparatively, the results obtained at the Lews works by myself.

The prices set down for peat, and for the products obtained from it, are the same in different cases, except in the statement of the working results of the Irish works in 1855. In that case the cost of the peat is set down as 4s. per ton, as reported in one of the official documents of the Company to have been the cost. The value assigned to the oil, in this case also, is not 5s. per gallon, as given in the Company's report, but 2s. per gallon, which I believe to be nearer its true value, and which admits of the results being compared with the other cases, in which that is the value set upon the oil.

The difference between the anticipated and the actual value of the ammoniacal salts, acetate, and naphtha, produced from the peat, is strikingly great, and I think it affords sufficient confirmation of the opinion I have already expressed as to the impropriety of regarding these products as constituting any source of profit in working peat, except when the manufacture of the other product is in itself remunerative.

But if these products are disregarded, the amount of oils and paraffin yielded by the Irish peat is so small, as compared with the cost of production, as to leave no possibility of profit. In addition to this it may be mentioned that the quality of the oil produced at the Irish works was very inferior, and bore no comparison to that of the oil produced at the Lews works. The manufacture of burning oil, indeed, was not attempted at the Irish works, in consequence of the offensive smell which the lighter portion of the oil possessed.

On the other hand, the yield of oils and paraffin from Lews peat is from three to four times as great as that obtained from the Irish peat, while the cost of working is but very slightly greater. The cost of peat in the two cases is also very different; for while in Lews the peat never cost more than 2s. 6d. per ton, and has since been obtained at a much lower rate, the cost of peat at the Irish works was 4s., and even as much as 6s. and 7s. per ton, a circumstance which in itself would be inconsistent with the possibility of working even such peat as that of Lews.

With these facts so clearly apparent, it is not a matter for surprise that the results obtained at the Irish works were not sufficient to afford a return for the enormous expenditure of capital on the works that were established; and to those who take an interest in the subject of peat working it must be a source of regret that the attempt to work the Irish peat was made and followed up with such rash precipitation and with so little preliminary examination of the capabilities of the material for working which such a large investment was made. Under any circumstances the working of peat is surrounded by many serious difficulties as regards both its establishment and prosecution. The districts where peat occurs are generally wild and remote, destitute of all those appliances and facilities for industrial operations which are to be met with in more cultivated parts of the country; the climate inhospitable and unfavourable for out-door work, and the inhabitants—accustomed to a rude mode of life, disliking work, and strenuously opposed to anything differing from their customary habits—are not easily trained to systematic labour. But these are not impassable barriers; they are merely obstacles which are to be overcome by patient perseverance, and, from the practical experience I have had of this subject during the last four years, I feel convinced that such peat as that occurring in the Western Islands and in the Highlands of Scotland, may be worked advantageously; and that, if the manufacture of these oils, which have now become such an important article of commerce, be carried out with earnestness and perseverance, it will become a means of greatly improving the condition of those districts in every respect, and a fertile source of profit to those who carry it out.

SHIPPING STATISTICS.—The following table supplies the number and tonnage of all registered vessels, both sailing and steam-propelled, belonging to each division of the United Kingdom, together with the number of the crews employed in navigating the same, in each of the five years from 1857 to 1861, inclusive:

		Vessels.	Tons.	Crews.
England ...	1857 ...	20,485	3,594,687	167,806
	1858 ...	20,868	3,675,181	168,603
	1859 ...	21,032	3,694,267	168,843
	1860 ...	21,007	3,709,615	168,415
	1861 ...	21,434	3,862,384	173,200
Scotland ...	1857 ...	3508	639,557	32,165
	1858 ...	3543	652,675	32,862
	1859 ...	3513	646,442	32,737
	1860 ...	3486	623,791	31,682
	1861 ...	3410	625,427	32,039
Ireland ...	1857 ...	2226	257,133	14,467
	1858 ...	2247	260,037	14,289
	1859 ...	2259	250,541	13,971
	1860 ...	2271	253,336	14,109
	1861 ...	2298	247,680	13,960
United Kingdom	1857 ...	26,219	4,491,377	214,407
	1858 ...	26,658	4,587,893	215,754
	1859 ...	26,804	4,591,250	215,551
	1860 ...	26,764	4,586,742	214,206
	1861 ...	27,142	4,735,491	219,199

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REVIEWS AND NOTICES OF NEW BOOKS.

Every Man's own Lawyer: a handy book of the principles of Law and Equity, comprising the rights and wrongs of Individuals, &c. By a Barrister. London: Lockwood and Co., 1863.

When Sugden the eminent lawyer produced a work somewhat similar to the one under notice, he was, we believe, the first who successfully condensed in a readable shape for non-professional men the principles of law and equity, in connection with the every day relations of individuals; but he very properly avoided the error of recommending every man to become his own lawyer.

The object with which the first work was written, has been very successfully carried out, and the vast number of subjects of which the book treats are very clearly placed before the reader.

This book must prove of great service to men of business, and we think "A Barrister" has not done himself full justice in the statement that the "price 6s. 8d. may be saved at every consultation," for we believe that a timely reference to this work may save the possessor from ruinous entanglement in the meshes of the law,

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A Practical Treatise on the Law relating to Mines and Mining Companies. By Whitton Arundell, Attorney-at-Law. London: Lockwood and Co., 1863.

This is another of the "handy books" relating to the special laws affecting Mines and Miners, and the author has brought together, in a conveniently small compass, a vast amount of valuable information on the nature of the property in mines, and its transfer; on mining partnership of various forms; on the working of mines, and the rights of owners and others. Of the rights of water and way; the rating of mines; of the Stannaries Court and its jurisdiction, and numerous other important and interesting matters in which most of those interested in mines, either as owners or investors, are deeply concerned.

Mr. Arundell's book should be possessed by every one interested in British Mines.

Contribution towards a History of Electro-Metallurgy, establishing the origin of the Art. By Henry Dircks, C.E. London: E. and F. N. Spon. 1863. Crown 8vo., pp. 120.

We have in this volume a collection of the papers written by Mr. Dircks during the years 1844-52 in various publications.

Professor Jacobi appears to have discovered a means of engraving by galvanism. and Mr. C. J. Jordan, of Liverpool, communicated a process he had invented for that purpose, and which, it is said, he published on the 8th of June, 1839. It also appears that Mr. T. Spencer wrote to the Liverpool Polytechnic Society on the 9th of May, 1839, stating he had an invention which he considered to be similar to Jacobi's, and that he would shortly communicate it, which promise he fulfilled, but not until the 12th of September, 1839. Mr. Dircks does champion for Mr. Jordan most valiantly, in the course of which the history of electro-metallurgy, and more particularly the special branch of that science to which we have alluded, is admirably brought out.

We consider that Mr. Dircks's work will for ever settle the question, and stamp Mr. C. J. Jordan, printer, as the true and first inventor of electro-metallurgy, through his publication of the process, on the 8th June, 1839. Mr. Dircks combats the question vigorously in all its minute ramifications, with candour, always keeping to the main point. It is not often that such investigations are carried through with equal good temper; and, considering it commenced in 1844, had to be taken up again in 1852, and is now published as a matter of scientific history, it is evident that Mr. Dircks is quite at home in this subject. We commend a perusal of the work to our readers.

The History of the Sewing Machine from the Year 1750. By N. Salamon. London: 8, Ludgate Hill, 1863.

In a pamphlet of over 100 pages, the author has given a history or biographical sketch of Mr. Elias Howe, the American inventor of the Sewing Machine which was first introduced into this country by him, but patented and known as Thomas's Machine, and which machine has since been improved upon and introduced to an enormous extent for sewing and manufacturing fabrics, and articles of almost every description.

The history of the Howe Sewing Machine in particular, and Sewing Machines in general, is one of great interest. Mr. Saloman attacks the present condition of the law relating to Patents for Inventions, and some of his strictures are deservedly, yet properly severe, but he is nevertheless a little at sea in this branch of his subject, whilst he is quite at home when he confines himself strictly to the history of the sewing machine.

NOTICES TO CORRESPONDENTS.

Aspel.—The vessel is fitted with Messrs. Randolph, Elder and Co.'s patent inverted cylinder engines, with internal gearing (iron). There are four cylinders (steam jacketted), viz. two of 62 in. diameter, and two of 31 in. 3ft. 3in. stroke. The piston makes 40 strokes per minute, and the screw makes 100 revolutions per minute. There are two tubular boilers 10ft. diameter, 16ft. long, fired at both ends, fore and aft, total heating surface, including super heater, 4200ft. There are eight furnaces, 3ft. wide by 4 ft. long; total fire grate area 96ft.; temperature of steam, 320°; pressure of steam, 37lbs.; vacuum in condenser, 28in.; surface in ditto, 2400ft.; tubes ¾in. diameter, 6ft. 6in. long.

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.

General Steam Navigation Company *v.* Mare.—This action was brought against the defendant, who formerly carried on business as a shipbuilder at Millwall, for breach of contract, by which he agreed to build a certain ship for the plaintiffs. The defendant became a bankrupt, but the bankruptcy was annulled, and he entered into a deed of arrangement with his creditors. At the trial, which took place at the Guildhall, before the Lord Chief Baron, a verdict was returned for the plaintiffs—damages, £290 8*s.* 8*d.* for stores, £709 17*s.* paid to his assignees for finishing the vessel, and £700 for penalties of £10 each for 70 days. The case now came before the Court upon a rule for a new trial, and in the course of the arguments it was agreed between the parties to draw up all the facts in the shape of a special case, and to bring it on again for argument.

Willis *v.* Davison.—In this case a rule nisi had been granted for a new trial. It was an action brought against the defendent to recover damages for the infringement of the plaintiff's patent for improvement in the manufacture of organs. The action was tried at Guildhall before Lord Chief Justice Cockburn, when the verdict was entered for the plaintiff, subject to leave reserved to the defendent to move to enter the verdict for him. The objects sought to be obtained by the invention were to give a rapid utterance to organ pipes of large dimensions with a decreased expenditure of muscular power on the part of the organist; to improve the effect of the swell organ, and bring the tones of the pipes in the swell box under more pefect command than heretofore; to steady the action of the bellows, levers, drawstops, swell shuttters, composition pedals, and like moving parts, and to prevent all unnecessary friction between vibrating arms and levers, and their bearings or chases—to bring the stops more thoroughly under the command of the performer, so that he could effect a variety of changes by putting in or drawing out such stops as might be required without the use of pedals as heretofore, and without removing his hand from the keyboard, and, lastly, to effect a saving of space, by improving the arrangement of some of the internal parts of the organ. After hearing the lengthened arguments of the learned counsel on both sides. The Court made the rule absolute to enter the verdict for the defendant. Rule absolute accordingly.

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 (for which we are chiefly indebted to the *Chemical News*), 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.

Machine Belting.—Messrs. Spill and Co., of Hackney Wick, have taken out a patent for machine belting, the peculiarities of which are that it is made of the best flax yarn, and woven into one solid mass by powerful steam-power looms, all this warp, or shuttle twine, being first soaked in water, so that the rack, on shutting the warp up into its place, may not meet with any of the opposition that hard yarn would present. The belting is made in three substances, and India rubber, of the very best quality, is passed on to the band while it is travelling through rollers, so that the gum may be squeezed into every opening, or partition, between the mass, thus rendering the whole more pliable, stronger, and about half the price, in wide bands, than is paid for leather. The bands in question can be laced with a common thong, in the same way as leather, and are equally free from trouble. No 3 substance has 90 warps to the inch, and each warp is capable of sustaining a strain of 50lbs. Official experiments applied to these bands testify to the above facts.

Preparing Iron Plates, &c.—The three months' trial of Mr. Roper's method for preparing iron plates, and of his composition for preventing the oxidisation of plates used for ships, having been concluded at Portsmouth, the test-plate, which had been immersed during the above-named period, was raised to ascertain its condition after the lengthened immersion. The result was most satisfactory to the inventor, and the plan was proved a success. The side prepared according to Mr. Roper's plan presented almost the same clean and even surface as it did when first immersed, while the reverse side, not having been prepared, was considerably corroded, thus proving the necessity of using the composition.

Asphaltum Oil.—Mr. Dollfus has discovered that the heavy oil, extracted from the asphaltum and bitumen of peckelbroun, is the best and most economic substance for preventing the incrustation of steam boilers. A thin coating of the oil is painted over the interior of the boiler every time the boiler is cleaned. By this means incrustation is entirely prevented, less fuel is required to keep up the steam, and the boilers do not burn out so fast.

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TRIAL OF STEAM FIRE ENGINES.—On the 15th ult., an interesting trial of the "Deluge" and Torrent, two engines constructed by Messrs. Merryweather and Son, took place at the West Ham Abbey Print Works, where every facility for this purpose was afforded by James Kayess, Esq., the proprietor. The "Deluge" is the engine which was exhibited in the International Exhibition last year, and the Torrent is a new engine of the class denominated "light steam fire engines" by the manufacturers. This engine can be easily drawn by a few men or one horse, more rapidly by a couple of horses, and has a cylinder 6¼in. diameter, with a 12in. stroke, the pump being double-acting, 4½in. diameter, with the same stroke as the steam piston; and, by a simple arrangement of the oiling apparatus, the piston lubricates itself at each stroke. The water passages and valves are placed beneath the pump, are easy of access, and there is no fear of freezing. They will allow the use of foul water without obstruction. The engine has no fly-wheel, but the slide is moved by a very ingenious arrangement, which enables a very slow or very quick movement of piston to be obtained at pleasure. The boiler is constructed in accordance with Messrs. Merryweather's patent, and does not prime. It has an injector for feeding, and can also be fed from the main pump. This engine is mounted on a strong wrought iron frame, and is attached to the fore carriage in such a manner that it can be taken over the roughest roads with ease and safety, and its high wheels and springs make it less liable to injury from rough work. Means are provided for carrying hose, suction pipes and all the necessary apparatus, with room for the men to ride, and it has coal bunkers and a water tank provided, so that it takes a sufficient supply of both to insure no loss of time in getting to work. The first trials were made at 9·30 a.m., when the Torrent, lifting the water between 5ft. and 6ft. (as did also the Deluge), worked through jets of 1in. and 1¼in.—also through two, one of ¾in. and one of ⅞in.—giving good proof that good work would be done through two ¾in. jets. The pressure in the pump never exceeded 120lb., and and that in the boiler averaged from 130lbs. to 140lbs. The chimney at the works,, 120ft. high, was easily topped by this engine through a 1¼in. jet, although the wind was blowing fresh. This engine did good work with a 1¼in. jet, which would have been very efficacious at a fire. Air vessels are fitted on each delivery, and near the suction pipes outlets are provided for attaching two lines of hose; and the engine will throw 250 gallons of water per minute to 160ft. in height. The following is the time and pressure of steam in the boiler from lighting the fire:—In 6¼min. pressure gauge moved; in 8 min., steam 2½lb.; in 8min. 30 sec., steam 5lb.; in 9 min. 10 sec., steam 10lb.; in 10 min., steam 20lb.; in 10 min. 15 sec., steam 25lb.; in 10 min. 30 sec., steam 35lb.; in 10 min. 45 sec., steam 45; in 11 min., steam 50lb.; in 11 min. 30 sec., steam 60lb.; in 11 min. 40 sec., steam 70lb.; in 12 min., steam 80; in 12 min. 10 sec., steam 90. The engine would have had steam much quicker had not the stop valve been kept open to warm the cylinder, which caused, in consequence, a rapid condensation of the steam. The Deluge threw a perfect column of water nearly half as high again as the chimney, the jets used being 1¼in., 1⅛in. and 1⅛in., all of which seemed to attain about the same height, and the pressure in the pump varied from 130lb. to 140lb., and that in the boiler from 120lb. to 130lb. The engine worked through four jets, each ⅞in. diameter, and had time permitted it was intended to have used four of ¾in., as it was plain that there was steam power over and above what would have been required for them. In 7½ min. from lighting the fire the gauge moved; in 9 min., steam 10lb.; in 10 min., steam 20lb.; in 10 min. 30 sec., 25lb.; in 11 min., steam 30; in 11 min. 30 sec., steam 40lb.; in 12 min. 10 sec., steam 50lb., when the engine started to work. An illustration and detailed description of the "Deluge" will be found in our series of ARTIZAN INTERNATIONAL EXHIBITION SUPPLEMENTS.

NEW REGULATOR FOR TEMPERATURES.—A Committee of the French Academy of Sciences reports very favourably of a new automatic temperature regulator which M. Eugene Rolland has attached to his mechanical roaster, and which, the committee say, has worked for eight years with the precision of a piece of physical apparatus and the certainty of a practical machine. The combustion of the furnace is regulated by balance valves on the pipes through which the air is introduced, which valves are automatically governed by the regulator. This regulator consists of a mercury guage, the closed branch of which is attached to a fixed support, while the cistern is freely suspended to the beam of a balance; the varying weight in this branch will cause the beam to assume different positions, depending on the temperature of the apparatus, which variation of position may be used to govern the valve. In order to prevent the barometric changes from affecting the apparatus, the closed end of a syphon barometer (the tube of which is of the same diameter with the guage) is attached to the beam, while its cistern is sustained by the fixed support. The barometric changes will then effect these two instruments equally and in opposite directions, and will, consequently, have no effect on the position of the balance beam.

BRAY'S RECENTLY MADE TRACTION-ENGINE.—A series of experiments have been made at Woolwich Dockyard before the principal officials with a view to test the efficiency of a new traction-engine, manufactured especially for dockyard work. The machine is at once a traction-engine, a steam derrick, and a portable steam-engine, and cannot, therefore, fail to prove economic in use. The total weight of the engine, boilers, and appliances complete is but 12 tons, and the pressure of steam which can be used is 120lbs. The cylinder is 7in. in diameter, and of short stroke, and the efficiency of the whole machine was really remarkable—a boiler of 28 tons weight being moved about, with the greatest facility by the use of the truck, whilst the derrick proved itself capable of raising between two and three tons with ease. It was shown that 10 miles per hour could be attained either on hard or soft ground. If, however, we are not mistaken, Mr. James Taylor, of the Britannia Works, Birkenhead, some time since constructed a machine which has been found to give very satisfactory results, and which appears to us to be nearly identical with this latest modification of Bray's traction-engine.

EXPORTS OF STEAM ENGINES.—According to the trade and navigation returns just published, an increase has been effected in the number of steam engines made and exported. In ten months ending October 31, last year, the value of steam engines sent abroad was £1,288,054. The value of the export in the ten years ending 1861, was as follows:—1852, £338,222; 1853, £458,376; 1854, £566,768; 1855, £883,370; 1856, £819,067; 1857, £1,089,249; 1858, £1,097,278; 1859, £973,340; 1860, £1,238,333; 1861, £1,243,467. It results from these figures that British steam engines were never in greater demand abroad than at present.

MILLWALL IRONWORKS.—Under the name of the "Millwall Ironworks and Shipbuilding Company" an association has been formed with £300,000 capital, which is all subscribed, to work with efficiency the extensive shipbuilding yard and rolling mills hitherto carried on by Mr. C. J. Mare, at Millwall. The yard where the *Great Eastern* was built, and which was purchased last year by Mr. Mare, forms a part of the premises of the new company.

CAPTAIN INGLIS'S TARGET.—About six months since, the result of experiments carried out at Shoeburyness, to test a target invented by Captain Inglis, attracted much attention from the fact that it was found capable of resisting rifled ordnance of a description which had easily pierced the strongest combination of iron plates and timber backing. Captain Inglis, having recently constructed a target with certain improvements, it has been subjected to a series of experiments, and a report has been made to the war department, highly favourable to the invention. The target consists of iron plates or bars placed across each other on a timber backing, and it has hitherto been scarcely affected by repeated attacks from Armstrong and Whitworth guns.

NEW DOUBLE-ACTING PUMP.—On the 10th ult. a series of experiments, with a view of testing the efficiency of the double-acting pump and fire-engine, invented by Mr. Delpech, were made at the wharf of Messrs. Francis, Son, and Potts, at Nine Elms. The arrangement of the apparatus consists of an external metallic casing, divided into two distinct portions, the one containing the cylinder in which the piston moves, and which is called the cylinder chamber, whilst the other contains four elastic balls, acting as valves or clacks, and is called the ball chamber. The cylinder chamber is divided into two parts by a diaphragm. This partition is provided at its centre with a round opening for the cylinder, which is open at both ends, and between its extremities and the chamber ends a space is left for the circulation of the liquid. The ball-chamber is also divided internally into two equal compartments by a vertical partition, each, however, communicating by a wide opening with one of the compartments of the cylinder. The principal feature of the pump, however, is the piston, which consists of two flexible cups, turned back to back, and kept in position by metal plates, considerably smaller than the diameter of the cylinder. The object of this arrangement is to reduce friction to the minimum. The advantages claimed for the pump are—that the liquid undergoes no interruption of motion from the dead point; that its effective force is extraordinary, as it yields nearly 70 per cent., and that mixture of ore, rags, or other foreign matter with the water does not interfere with its working, all things not exceeding one-half the diameter of the suction-pipe being easily pumped through. It will at once be seen that the principle of the pump is precisely the same as that involved in Warner's double-acting pump, and Godwin's flood-pump, as well as some others; but Mr. Delpech has introduced modifications, or improvements, in the piston, which cannot fail to pack very tight, and in the substitution of ball-valves for the usual clack-valves.

NAVAL ENGINEERING.

THE COLUMBINE, 4, screw steam gunvessel, 200-horse power has been taken out of the fittting basin at Sheerness, and after being fitted with Lumley's patent steering apparatus, was on the 23rd ult. taken to the measured mile off Maplin Sands for trial. The vessel was in charge of Capt. Charles Wise, A.D.C., Captain Superintendent of Sheerness Dockyard. As previously reported in *The Artizan*, the *Columbine* was fitted with the ordinary rudder and taken out on trial on the 16th of December last. This was with a view to compare the results. At the first trial, with the old rudder, at full speed, helm starboard, at an angle of 23 deg., the circle was made in 4 min. 26 sec.; with the new rudder, helm starboard, at an angle of 17 deg., the circle was made in 4 min. 10 sec. At the second trial, with the old rudder, from dead stop, helm starboard, at an angle of 35½ deg., the circle was made in 4 min. 30 sec.; with the new rudder, at an angle of 30 deg., the circle was made in 4 min. 15 sec. At the third trial, with the old rudder, at full speed, helm port, at an angle of 18½ deg, the circle was made in 5 min. 5 sec.; with the new rudder at an angle of 18 deg., the circle was made in 4 min. 10 sec. At the fourth trial, with the old rudder, from dead stop, helm port, at an angle of 32 deg., which fell off to 27 deg., the circle was made in 4 min. 28 sec.; with the new rudder, at an angle of 30 deg., which fell off to 26 deg., the circle was turned in 4 min. 20 sec. At the fifth trial, with the old rudder, at full speed, helm starboard, at an angle of 11 deg., the circle was made in 7 min. 48 sec.; with the new rudder, at an angle of 10 deg., the circle was made in 5 min. 40 sec. At a similar trial with the old rudder, with the helm to port, the circle was made in 7 min. 20 sec., and with the new rudder in 6 min. 40 sec. The comparative diameters of circles were:—Second trial, with old rudder, 818ft.; new rudder, 625ft. Third trial, old rudder, 1,450ft.; new rudder, 782ft. Fourth trial, old rudder, 551ft; new rudder, 291ft. Fifth trial, old rudder, 673ft.; new rudder, 469ft. When testing the power of the old rudder the trial was made on a calm day, and with little or no wind. The trial of Lumley's rudder on the 23rd ult. was made in a heavy sea, with a heavy gale of wind blowing from SS.W., the force of wind being from 7 to 8. Capt. Wise, with a wish to test the strength of the new rudder in the most efficient manner possible, turned the *Columbine's* stern up to the wind in the teeth of the gale then blowing and against the heavy sea, and directed the ship to be steamed astern full speed, which the rudder answerd in a most admirable manner, proving the strength and efficiency of the invention when applied to heavy and powerful vessels, and under the most unfavourable circumstances. The most marked improvement was evident when the small helm was given, such as 11 or 12 deg., the Lumley rudder then gaining as much as two minutes in describe the circle over the old rudder. The diameters of the circles—the true test of the efficiency of a rudder—were found to be in some cases as much as 50 per cent. in favour of the Lumley invention. The trial was considered most satisfactory.

THE "PYLADES," 21, 1278 tons, has taken her final trial trip, at the measured mile off Maplin Sands, previous to her departure to the West Indies. The *Pylades* is fitted with Penn's horizontal direct-acting trunk engines, of 350-horse power, which worked extremely well. There was an entire absence of all hot bearings, priming, or any perceptible vibration from the machinery. The results of the trial were:—Average speed, 10·373 knots per hour; revolutions of engines, 63; vacuum, 25; pressure of steam, 20lbs. Griffith's screw, pitch, 20ft.; diameter, 15ft. 9in.; draught of water forward, 15ft. 9in aft, 19ft. 7in.

FRENCH NAVY.—The following is taken from the report of the French Minister of the Marine. At the present time the number of steam vessels of war composing the active fleet amounts to 136, including the 24 gunboats afloat; but, only taking into account the five descriptions of vessels set down in the tables of 1862, the number is only 112, divided as follows:—

	New Vessels.		Mixed Vessels.		Totals.
Line of Battle Ships,	13	...	23	...	36
Iron cased Frigates,	4	...	—	...	4
Ordinary Frigates,	18	...	6	...	24
Corvettes,	7	...	—	...	7
Advice Boats,	41	...	—	...	41
	83		29		112

The above list gives for the new fighting fleet an increase of 11 vessels completely fitted out, viz:—one line of battle ship, of 900 horse power, which has been a long time on the stocks; two iron cased frigates; three ordinary frigates; and six advice boats. But on the other hand one vessel has been lost at sea, and eight belonging to the old fleet have been condemned as no longer fit for service. Lastly, there are afloat, nearly completed, or making experiments, two iron cased frigates, one ordinary frigate, two advice boats, one gunboat, and two floating batteries.

THE "PRINCE ALBERT."—A large number of workmen are now employed at the premises of Messrs. Samuda upon the construction of Her Majesty's armour-plated screw cupola ship *Prince Albert*. She will be iron cased throughout with 4½in. plates, and fitted with four armour cased shields or cupolas, of immense strength, upon Captain Cole's plan recently adopted by the Admiralty. She is the first cupola ship laid down for the government, and is named the *Prince Albert* by express desire of Her Majesty. The armament of this magnificent vessel will consist of eight monster rifled guns, two of which will be fitted in each cupola.

THE RUSSIAN GOVERNMENT has commenced the development of an iron navy. Messrs. C. Mitchell and Co., shipowners of Newcastle-on-Tyne, have been entrusted with all the arrangements necessary to convert the Government dockyard at St. Petersburg into an iron shipbuilding yard. Steam engines, punching, shearing, and other machines of the most modern construction, have been sent from Manchester and London. A railway will traverse the dockyard and communicate with the workshops and building slips. Steam travelling cranes will be erected over the vessels in course of construction, thus performing the greatest amount of work by means of mechanical appliances.

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Loss of the Monitor.—This famous American iron clad cupola steamer foundered at sea, south of Cape Hatteras, in a heavy gale on the 29th December last, whilst on her voyage to one of the Southern Ports. We have, on another page, given two illustrations of this vessel.

Screw of the "Royal Oak."—This iron clad frigate shipped her spare screw, at Chatham dockyard, on the 17th ult. The screw-blade of the propeller is Griffith's, which by a recent decision of the Admiralty, is now supplied to all screw ships of war. In the case of the *Royal Oak*, however, the screw has been subjected to some alterations and improvements by Messrs. Maudslay, the most important of which appears to consist in bolting the screw blades to the "boss" with flanges instead of fixing them with the key and wooden wedges. By this arrangement the blades are more securely attached, while the pitch of the screw may be readily varied when required, an advantage not to be obtained in the present construction and fittings of Griffith's screw. The diameter of the screw is 19ft. 3in., and by the improvements introduced its pitch can be easily and rapidly varied from 22ft. 6in. to 27ft. 6in., with an ordinary pressure of 20lb. of steam to the square inch. The screw will make 60 revolutions per minute. The length of the iron shaft for working the screw is 109ft., and the weight of the screw 19½ tons.

The New Yacht ordered to be constructed for the use of Her Majesty when at Osborne will be built at Pembroke Dockyard, according to designs furnished from the office of the Controller of the Navy. She will be propelled by paddles driven by engines of 160-horse power, from the manufactory of Messrs. J. Penn and Son, will be of considerably more tonnage than the *Fairy*, and will have a somewhat different midship section from that vessel. The *Fairy* has stood unrivalled for a number of years past, either in beauty of form or rate of speed, but the peculiar roundness of her bottom has rendered her a very uneasy vessel in crossing Spithead during a south-east breeze. Her Majesty has experienced much inconvenience and personal discomfort at times in consequence. The *Victoria and Albert* large paddle yacht has been used on several occasions to convey the Queen when there was very rough weather, but, as she could not approach either of the landing places at Cowes or Haslar, the *Fairy* had still to be retained as a means of transport to and from the large yacht. This again has been a cause of much personal discomfort and delay to Her Majesty. The new yacht will supply the means of crossing between the Isle of Wight and the main, under any circumstances of weather, in comfort and in safety.

Iron-built Armour-Plated Vessels.—On the 19th ult., Mr. T. Barras read a very interesting paper in the theatre of the Royal United Service Institution, on the proposed plan for a wholly iron-made armour-plated vessel. Captain Fishbourne, R.N., occupied the chair. The view taken by Mr. Barras of the subject was of a three-fold character. He said that a ship such as he proposed should be regarded hydrostatically, as a body designed to float; mechanically, as a beam subject to great pressure; and in the third place as a battery designed for purposes of attack and defence. A ship to be constructed on his principle should have a flat bottom amidships, where the boilers and coal bunkers were, and should be constructed wholly of iron, in three sheets of iron plates, riveted together in such a manner as to be protected either by an outer or inner coat of the plating. He strongly objected to a ship built of mixed materials differing widely from each other in chemical properties, as they never could work in harmony together. One point connected with the present construction of ships demanded consideration, and that was the destructive electrical action which took place in salt water with mixed constructions of iron and wood, with fastenings of brass. It was this electrical action that caused the high ratio of illness occurring in the finest armour-plated ships, and the curious results elicited by *La Gloire*. As for the present system of shipbuilding, the probable results might be anticipated—the most serious and ruinous expenses would be gone to on ships that could not be expected to last for a dozen years; while a ship constructed as he proposed, he ventured to affirm would be an efficient ship for half a century, it not longer. Mr. Barras entered into particulars, tending to show that the vessel thus put together would answer all purposes for which she would be required.

Ventilation of Iron-cased Frigates.—The plan of ventilation which is now being carried out on board the frigate *Royal Oak*, under the direction of Capt. Fanshawe, who is the inventor of the system, differs in several respects from the method hitherto adopted for securing ventilation for our large line-of-battle and other ships. As applied to the *Royal Oak*, and other armour-plated vessels of the same class, it promises to be exceedingly effective. In securing a ventilation of the main deck, comparative little difficulty will be experienced; it is therefore in the lower deck that the method recommended by Capt. Fanshawe will be more particularly adopted. The masts of the *Royal Oak*, being of iron, and all hollow, advantage is taken of this to make them air-shafts for carrying off the vitiated air from each deck. An aperture is accordingly made in each mast, which being opened and closed at pleasure, permits the foul air of all the decks to be carried upwards. The different berths, stores, and compartments on the deck, instead of being closed up as in ordinary vessels, are supplied with gratings by which the foul air may escape. The essential point in Capt. Fanshawe's system is that there shall be a constant current of air circulating in every portion of the vessel, approximating as closely as possible to the upward and downward currents of a mine.

The Danish Navy.—A list of the Danish navy and its officers has lately been published, from which is derived the following information. The Danish fleet, which for the last year has been growing in numbers, has now begun to diminish on account of the sailing vessels being given up altogether, and partly sold, and partly going to be sold. There only remains two ships of the line, two frigates, two sloops, two brigs, and one cutter. Of screw propellers there are in the water, one ship of the line of 64 guns, four frigates of respectively 44, 42, 42, and 34 guns, three sloops of 16, 16, and 12 guns; two iron-clad schooners and one wooden schooner, each of 3 guns; further, six iron screw gun boats, each of two guns; eight paddle steamers, with from 2 to 7 guns; and 50 guns boats, and 28 transport ships. Moreover, the former ship of the line, *Dannebrog*, is being altered into an iron-clad screw sloop of 400-horse power, with fourteen 60lb. guns, and one heavier gun; and the screw frigate *Peder Schram*, of 600-horse power and 56 guns, and a screw schooner of 150 horse-power and 3 guns, are far advanced. The corps of officers numbers 4 admirals, 29 captains, 23 lieutenant captains (commanders), and 85 lieutenants.

The Royal Navy.—The following statement of the condition of the Royal navy at the present time has been compiled from authentic sources. It shows that there are 287 vessels in commission, doing duty in various parts of the globe. The total number of vessels is made up as follows: 5 iron screw ships from 16 to 40 guns each, 3 iron-cased ships of 34 guns each, 1 iron-cased screw cupola ship of 5 guns, 67 screw ships from 31 to 131 guns each, 37 screw frigates from 6 to 51 guns, 26 screw corvettes from 13 to 22 guns, 36 screw sloops from 4 to 17 guns. 4 screw floating batteries from 14 to 16 guns, 4 screw mortar ships of 12 guns each, 2 iron screw floating batteries of 16 guns each, 1 iron screw sloop of 8 guns, 1 iron paddle sloop of 6 guns, 1 iron screw yacht, 1 iron screw troop ships from 1 to 8 guns, 6 iron screw store ships ftom 1 to 4 guns, 15 iron paddle vessels from 1 to 6 guns, 1 iron screw vessel, 1 screw surveying vessel of 5 guns, 47 screw gun vessels from 1 to 6 guns, 1 screw store ship, 26 paddle vessels from 1 to 6 guns, 27 paddle sloops from 3 to 6 guns, 15 paddle frigates from 6 to 28 guns, 4 paddle yachts, 2 paddle store ships of 4 guns each, 1 Royal yacht, 3 paddle surveying vessels, 10 paddle tug vessels from 1 to 3 guns, 2 paddle gun vessels of 3 guns, 134 sailing ships, 160 screw gunboats, 141 non-effective ships, hulks, &c., engaged in harbour service, and 48 coast-guard tenders. The ships now building comprise: 5 iron screw ships, 4 iron cased screw ships, 1 iron cased screw cupola ship, 1 iron cased screw corvette, 1 iron cased screw sloop, 3 screw ships, 4 screw corvettes, 6 screw frigates, 6 screw sloops, 5 screw gun-vessels, 9 screw gun-boats, and 12 paddle despatch vessels.

Naval Appointments.—The following Naval appointments have taken place since our last:—B. Foreman, Engineer, to the *Osprey*; J. Hill, Engineer, to the *Cumberland*, as supernumerary; J. Stiven, in the *Edgar*, promoted to Engineer; J. P. Lloyd, in the *Sanspareil*, T. Burnett, in the *Asia*, J. Turner (B), in the *Galatea*, W. Todner, in the *Cumberland*, A. Waters, in the *Swallow*, E. Eckersley, in the *Hastings*, for the *Lark*, W. Fedarb, in the *Porcupine*, J. T. Page, in the *Hastings*, for the *Sandfly*, and H. Knight, in the *Hawk*, promoted to the rank of Engineers; W. Inglis (A) and J. R. Hancock, First-class Assist. Engineers, and J. M. Brankston, Second-class Assist. Engineer, to the *Osprey*; C. M. Keever, First-class Assist. Engineer, and W. M'Glashan, Second-class Assist. Engineer, to the *Cumberland*; W. H. Wheatley, First-class Assist. Engineer, to the *Fox*; J. M. Murphy, First-class Assist. Engineer, and C. Wakeman, Acting Second-class Assist. Engineer, to the *Majestic*; R. Sampson, Chief Engineer, to the *Sampson*, for the *Prince Consort*; J. Ashley, Chief Engineer, to the *Asia*, for the *Arrogant*; J. Barr, supernumerary in the *Asia*, promoted to First-class Assist. Engineer; T. Huard, engineer to the *Caradoc*; W. Todner, Engineer to the *Cumberland*, for the *Bullfrog*; J. Donne, Engineer, to the *Triton*; J. Bowman, and J. Gissing, First-class Assist. Engineers, and W. Hopkins and J. Kelly, Second-class Assist. Engineer, to the *Caradoc*; C. Bulford, First-class Assist. Engineer, to the *Asia*; F. W. Robinson, First-class Assist. Engineer. and W. Walker, Second-class Assist. Engineer, to the *Triton*; R. E. Ramsay, Acting Second-class Assist. Engineer to the *Triton*; J. G. Bain, in the *Wesser*, promoted to Acting First-class Assist. Engineer; R. Holman, Chief Engineer to the *Alecto*; C. M'Keever, Fist-class Assist. Engineer, and W. M'Glashan and F. S. Scott, Second-class Assist. Engineers, to the *Alecto*.

MILITARY ENGINEERING

Practice against Armour Plates.—Some interesting firing at 4½in. and 5½in. armour-plates, took place at Portsmouth on the 21st ult. The plates to be tested comprised, one from the Atlas Iron and Steel Works, Sheffield, (Messrs. John Brown and Co.,) and two from the Millwall Iron and Shipbuilding Company's Works, (late C. J. Mare & Co.) The first was a 4½in. plate for Mr. Reed's iron-cased corvette *Enterprise*, 9ft. 4½in. in length, and 3ft. 7in. in width. The Millwall plates were sample plates for the *Northumberland*, building in that yard, and were 5½in. thick, one inch in excess of the Atlas plates. One plate was annealed, and 8ft. 3in. in length by 3ft. 2½in. in width. The other plate was "tempered," and, with the exception of 1½in. less in width, was of the same dimensions as the one annealed. All the plates were bolted on to the side of the *Powerful*, target-ship, in Porchester-creek, and the firing was made from the *Stork's* 95cwt. 68-pounder smooth bore gun, at the customary 200 yards' distance. One shot was first fired at each plate in its turn, when the firing was suspended to allow of an examination being made of the effects produced. The annealed plate was found to have been struck by the shot 17in. from its upper edge at its left extremity, the depth of the indent being 2in., with a diameter of 9in., a crack extending across the corner of the plate from the line of the first square to the bottom line of the same square, or central line of the plate. Another crack was visible below the circumference of the indent, about 5in. in length. The tempered plate was struck in the bottom corner of the second square and had buckled outward at either end to the blow, but was without cracks. The depth of the indent was 1in. and 9-10ths, and the diameter 9in. There were no visible cracks. The 4½in. plate from the Atlas Works was struck on its left centre, the indent being, in this case also, 1in. and 9-10ths, and the diameter 9in. The plate was not buckled, and only a slight appearance of separation of metal was visible, and that was in the centre of the plate struck. and was apparently the outer surface of the metal rubbed up by the blow. From this the firing was carried on at each plate, with intervals between to allow of the necessary examination, until the two Millwall plates had each received five shots on their left ends from the centre, the Sheffield Atlas plate eight shots in the same quarter. The Millwall plates proved, as had been expected by their makers, incapable of resisting the blows of the 68-pounder; and separation of metal, as well as penetration of the ship, in their case was perfect. With the Atlas plate the case was more satisfactory. The plate proved of excellent quality, and, although subjected to severe straining blows on its left edge and lower left corner, and to six blows all delivered within a very small space, and in two instances overlapping each other, there were no cracks from individual blows to bolt holes or other weak parts. The separation of metal that took place, irrespective of the edge and corner blows, was caused by the pounding of the shot in one particular space, and the consequent tearing asunder of the metal. The ship's side was clear of anything like penetration. The plates from Millwall were stated to be purely experimental, which, it is also asserted, fully accounts for their failure. The work is new to the company, and, as they are about to embark largely in it, even the failure of a few plates may be turned to an ultimate source of profit. The Thames Ironworks and the Atlas Iron and Steel Works gained their position as the acknowledged best makers of hammered and rolled armour plates respectively only after numerous failures and a heavy outlay. The Millwall Company profiting by the experience of others, made public since armour-plate forging first began, may attain a position in the first rank without such great losses. The Millwall plates were forged under the hammer, while Mr. Brown's plates were rolled. The last two years' experience, and more especially that of the past twelvemonth, has, however, proved that tougher and more perfect armour-plates can be made with the rollers than with the steam hammer. Of this fact the trade generally seem to be fully aware. The Sheffield Atlas Works now roll plates up to 7½ in. in thickness, and can make them of any required length or breadth. At the same works there is also being erected rolling machinery that will turn out plates 12in. in thickness, and still thicker if required. The Millwall Company are also erecting rolling machinery for 12in. plates.

French Ordnance.—A gun entirely built of steel, and composed of several tubes of that metal, put together in the method introduced in France by Colonel Trenillee de Beaulieu, but better known in England as "Blakeley's" plan, and which secures the simultaneous action of all the tubes in resisting the bursting force of the powder, has been recently tried in that country. The gun weighs only 4½ tons and a few pounds, or nearly 3 tons less than the Armstrong rifled or the Whitworth plan. The French gun is rifled with three grooves, less than a quarter of an inch deep. The twist of the rifling is uniform, one turn in 30 calibres, being a slightly quicker turn than that used by Armstrong, and a little slower than that used by Cavalli and Whitworth. The gun, when last heard of, had been fired 800 times without injury. The shell weighs 45 kilogrammes, or between 99lb. and 100lb. The service charge of powder is 12½ kilogrammes, or about 28lb., although in some cases 15 kilogrammes, or 33lb. of powder, were used.

STEAM SHIPPING.

New Steam Tug "Columbus."—Messrs. Laird Bros., of Birkenhead, have just completed a new steam tug, called the *Columbus*, fitted with a pair of their disconnecting diagonal engines, 90 horse power, nominal. Speed being now a great object with tug-boats, as with all other ships, the *Columbus* was built to combine great speed with first-rate towing qualities, and on her first trial in smooth water she attained a speed of 14 knots, her engines indicating 7½ times the nominal or 650 effective horse power. On her final trial she run to Holyhead and back. She accomplished the run, although she had considerable sea and wind to contend against, at an average rate of 12½ knots per hour, with a moderate consumption of fuel.

Iron Shipbuilding in Liverpool.—Owing to the unprecedented demand for iron ships, and the high reputation Liverpool has attained for building iron sailing vessels, the yards during the past year have been in greater activity than was ever known before. This demand is attributable to the fact that iron ships can now be built at considerably less cost than wooden ones, and are in point of durability superior. The formation

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of an underwriter's association, at Liverpool, to class iron vessels on their merits for periods varying up to 22 years, has had the effect of causing Lloyd's to alter their rules, which had hitherto militated against progress in iron shipbuilding. At a rough estimate the tonnage of iron vessels built, in Liverpool, during 1862, may be set down at 20,000 tons, and the tonnage of wooden ones at 6000. This, however, is exclusive of the vessels built by Messrs. Laird, of Birkenhead, whose operations have been very extensive, as may be judged from the fact, that they have, at present, orders on hand to the extent of between 18,000 and 19,000.

LAUNCHES OF STEAMERS.

LAUNCH OF THE "PAULET."—Messrs. C. Mitchell and Co. launched from their building yard at Low Walker, on the 10th ult., a large screw steamer for the service of the Intercolonial Royal Mail Steam Packet Company, and destined to carry mails between Australia and New Zealand. The vessel is named the *Paulet*, and is of the following dimensions:—Length, 228ft.; breadth of beam, 38ft.; depth of hold, 16ft. 6in. As ventilation is the chief element of comfort in a steamer built to carry passengers, this object in construction has been specially kept in view in the *Paulet*. She is not only provided with a lofty saloon, numerous skylights and side-ports, but a separate steam engine is to be erected for the purpose of thoroughly ventilating the holds, cabins, and engine-room; and so completely will the system be carried out that each private cabin will be provided with a ventilating tube. The machinery for the *Paulet* is of 150-horse power, and has been manufactured by Messrs. R. Morrison and Co. of Newcastle. Economy in consumption of fuel has been carefully kept in view, the engines being furnished with surface condensers and other fuel-saving appliances. The *Paulet* will proceed under steam to Australia, and will form a valuable addition to the Intercolonial Company's fleet.

LAUNCH OF THE IRON SCREW STEAM SHIP "TAMAR."—Another important addition was made on the 6th ult., to the Royal navy by the launch of the iron screw steam vessel *Tamar*, of 2311 tons, and 500 horse power, from the premises of the builders, Messrs. Samuda, Poplar. The *Tamar* will be fitted with her screw machinery and engines, by Messrs. Ravenhill, Salkeld, and Co. The *Tamar* was laid down in November, 1861, and is in every respect a fine specimen of modern naval architecture. She is a smart looking craft, and well adapted for speed. The following are her principal dimensions:—Length 300ft.; breadth, 44ft. 7in.; depth in hold, 34ft.; burden in tons, 2811, 82-94, old measurement. After receiving her machinery she will be removed to Woolwich dockyard to be rigged, and fitted with her armament, consisting of four rifled guns, and she is expected to be ready for service by April next.

LAUNCH OF THE "STAR OF THE SOUTH."—On the morning of the 24th ult. this iron screw steamer, built for Messrs. Broomfield and Whittaker, of Sydney, and intended for the coal and coasting trade of Australia, was launched from the yard of Messrs. Wigham, Richardson and Co. Low Walker. Her dimensions are as follows:—Length 130ft.; breadth 21ft. 6in.; depth, 9ft. 6in.; and to carry 200 tons of coal. She will be propelled by direct acting engines, by Messrs. R. and W. Hawthorn, of Newcastle, 45-horse power. After the launch the vessel was towed to Newcastle, when her machinery was fitted, and in the afternoon she returned to her builders' yard under her own steam in the short space of ten hours from leaving her ways.

THE "PRINCESS ALEXANDRA," iron paddle steamship, was launched on the 20th ult. from the yard of the Thames Ironworks, Blackwall. The *Princess Alexandra* is about 500 tons, and has been built for the service of the Trinity House, Dublin. She will be engined by Messrs. Penn.

TELEGRAPHIC ENGINEERING.

TELEGRAPHIC CABLE FOR THE PERSIAN GULF. The Indian Council have decided on a submarine cable across the Persian Gulf. They have not given over this undertaking to any company, contractor, or concessionaire. The whole management of this national work is entrusted to one of their own officers, Colonel Stewart, R.E. The core will be gutta percha, made at the Gutta Percha Company's Works, Wharf-road, London. It will be tested by Reid's process of pressure, equal to the depth of the sea where the cable is to be laid. Mr. Henley, of North Woolwich, will make the iron sheathing, and our own Government ships will submerge it. From the specimen already constructed, it is admitted to be the best submarine cable yet made, and there is no doubt it will prove so. The whole will cost about £300,000.

TELEGRAPH EXTENSION IN NEW SOUTH WALES.—The Colonial Parliament has agreed to the following telegraphic extensions during the current year:—From Deniliquin to Hay, a length of 80 miles; from Wellington to Dubbo, 35 miles; from Braidwood and Queanbeyan, 35 miles; and also an additional wire on the posts between Sydney and Newcastle. The telegraph to Kiama, which passes through Campbeltown and Wollongong, was opened on the 16th of October, with the usual congratulatory message from the Minister for Works. Kiama is conveniently situated on the coast for the observation of vessels coming towards Sydney from the southward, and the station-master is instructed to report to the telegraph office in Sydney, for public information, the names of vessels passing sufficiently near to the port to be distinguished. The telegraph to Forbes (the Lachlan diggings), on the extension from Orange to Wagga Wagga, was opened in November. The line will next be carried on to Burrangong. The extension from Tenterfield to Grafton, a length of 123 miles, was finished in November last.

TYPO-TELEGRAPH.—An extensive series of experiments are being made in France with the Typo-Telegraph, invented by M. Bonelli, by which 500 despatches of 25 words each, can be printed within an hour. Should the experiments prove satisfactory, it is intended to introduce this telegraph on the principal railway lines in France.

SUBMARINE CABLE BETWEEN SARDINIA AND SICILY.—A submarine cable has been most successfully laid between the port of Cagliari, in the island of Sardinia, and Napani, in Sicily, a length of 200 miles.

RAILWAYS.

THE METROPOLITAN RAILWAY.—The Metropolitan Railway was opened on the 10th ult., to the public, and trains continued running from six o'clock in the morning till a late hour at night. There was a great wish on the part of the public to make trial of this novel mode of metropolitan intercommunication, and small was the chance of obtaining a seat in the carriages anywhere but at the Paddington station. This was in the early part of the day, for the traffic all set in City ward; the few who had the wish to proceed westward finding ample accomodation and comfort in their experimental trip. It was soon found that the engines and rolling stock of the company were not sufficient to accomodate the crowds of passengers; and a loan of both engines and carriages was obtained from the Great Western; but even these did little to mitigate the evil, as, indeed, the addition of any number of trains to those provided by the company was attended with some danger. So great had the pressure become that about midday it was announced to the crowds collected at the different stations that their chance of proceeding down the line was hopeless, as there was then collected at the Paddington terminus passengers enough to fill the next four or five trains. In the afteanoon the tide turned, the flow of passengers proceeding westward; and then the pressure became as great at the Victoria terminus at the east end. Some discouragement arose from the accumulations of smoke and steam in the long tunnel, which appeared, contrary to the sanguine anticipations of the engineers that there would be neither smoke nor steam from their engines. The annoyance was still greater on the following day, and even rose at one time to a serious height, as many of the passengers complained of headaches, and there was hardly a guard, pointsman, or station master who did not suffer from the foul atmosphere, and were obliged to be led in some instances into the fresh air.

EXTENSION OF THE METROPOLITAN RAILWAY.—This Company propose to take Parliamentary powers to purchase additional lands for the purpose of their undertaking, and for enlarging their powers of compulsory purchase of property in respect of the incomplete portion of their western extension in the parish of Paddington, near the junction of South Wharf-road with Praed-street, to the southern end of Eastbourne-terrace, where it forms a junction with Conduit-street, and also as to the incomplete portions, comprising the line to the intended Metropolitan Meat and Poultry Market, and the Finsbury-circus extension. The particular lands and properties supposed to be taken are in the parish of St. Giles Without Criplegate, near or between the streets called Little-Moorfields, New Union-street, Moor-lane, and Tenter-street; and between Whitecross-street, Milton-street, and Moor-lane, on both sides of the extension to Finsbury Railway, and between Vine-court and Maidenhead-court, adjacent to Moor-lane. The lands and buildings proposed to be taken in the parish of St. Sepulchre and Liberty of Glasshouse-yard, are in and near Cow-cross-street and Sharp's-alley, Charterhouse-lane and Charterhouse-square, and northwards of the limits of deviation defined by the Finsbury-circus Extension Act. Those at Paddington are in, near, and between Conduit-street, Spring-street, London-street, and Conduit-place.

METROPOLITAN, KNIGHTSBRIDGE, AND KENSINGTON JUNCTION RAILWAY.—It is proposed that this extension of the Metropolitan Railway shall run out of it where it crosses London-street, Paddington, and terminate near the western bank of the Serpentine, north-west of the bridge between Hyde-park and Kensington-gardens, with branches from the termination of the latter line to a point in Hyde-park abutting on the Knightsbridge-road, westward of the lodge at the entrance to Hyde-park corner, together with a further extension to near the junction between Young-street to High-street, Kensington at an estimated cost of £600,000.

METROPOLITAN, TOTTENHAM, AND HAMPSTEAD RAILWAY.—This extension of the Metropolitan Railway is intended to start from near the eastern end of their Gower-street station, in the Euston-road, St. Pancras, and terminate on the South side of Swain's lane, at a point east of the Highgate-road. It is estimated to cost £400,000.

BARNES, HAMMERSMITH, AND KENSINGTON RAILWAY.—The route of this new line will commence at Barnes, near the curve of the Richmond and Windsor line, and run through Hammersmith and Kensington, terminating on the West London Extension-railway, about 440 yards south-east of the point where that railway passes under the Hammersmith-road. The next branch will start from Kensington Hall and terminate at Earl's Court-road, and other branches will run to the Victoria-road, Kensington, to the loop line carrying the Kew and Hounslow line over the Thames from Barnes, and from the south-west extremity of York-place to a junction with the Hammersmith and City terminus at Hammersmith. The capital estimated to be required tor the line is £340,000.

AGREEMENTS BETWEEN THE GREAT WESTERN RAILWAY AND THE SOUTH WESTERN, AND NORTH WESTERN COMPANIES.—A circular has been issued by the Great Western Railway Directors, informing the shareholders "that in conjunction with the West Midland Company, they have entered into two separate agreements; the one with the London and South Western Railway Company, and the other with the London and North Western Railway Company. The main object of these agreements is to utilise existing lines by increased facilities being given to each other, thereby affording improved accommodation to the public, and avoiding expenditure by the projecting of new lines, which might tend to unnecessary or injurious competition. The agreements for amalgamation of the West Midland and South Wales Companies with the Great Western are presented, for confirmation by Parliament, in the approaching Session. The only bill for a new work promoted in this Session by the Great Western Company is to complete a short junction at Great-bride, in South Staffordshire, between two lines already formed, and for which provision is made under an agreement with the London and North Western. The directors add that they have thought it desirable to place these facts before the shareholders, and that they will be prepared, when they meet the proprietors in February, to afford a full explanation of these matters.

DOVER, DEAL, AND SANDWICH RAILWAY.—The route of this new line will be by a junction from the Shepherdswell station of the London, Chatham, and Dover, to Albert-terrace, Deal; then from the latter line between Eastry and Ham to the the South Eastern Railway at Sandwich, near the Sandwich Gas Works, at an estimated cost of £100,000.

GREAT EASTERN RAILWAY.—This company is about to place ten additional passenger and thirty additional goods engines upon its railways, at a cost of £100,000. The intended acceleration of the train service has been posponed for the present.

CHARING-CROSS AND SOUTH-EASTERN RAILWAYS.—It is proposed to amalgamate the Charing-Cross and South-Eastern Railways, on such terms and considerations as the two companies may think fit, subject to the terms and considerations being sanctioned by three-fifths of the votes of the shareholders in each company. The agreement is to take effect either before or after the completion of the works of the Charing-Cross line, which are now in course of construction.

NORTHERN OF FRANCE RAILWAY.—The traffic receipts on the old lines of this company during the year 1862 amounted, on 631 miles, to £2,630,100, and for the year 1861, on 605 miles, to £2,582,757, showing an increase of £37,403, or, 1·44 per cent. The total receipts on 66 miles of new line amounted, for the year 1862 to £107,953, and for the preceding year to £20,538, showing an increase of £87,365.

SOUTH AUSTRIAN AND LOMBARDO-VENETIAN RAILWAY.—The total traffic receipts on the South Austrian line, 1004 miles in length, amounted for the year 1862 to £2,264,038, and for the year 1861 to £2,260,486, showing an increase of £3,552. The total traffic receipts on the Lombardo-Venetian line, 216 miles in length, for the year 1862, amounted to £334,465, and for the year 1861, on 199 miles, to £262,625, showing an increase of £71,840. The total receipts on the two lines last year amounted to £2,538,503, and for the preceeding year to £2,523,111, showing an increase of £75,392, or about 3 per cent. The traffic receipts on the Central of Italy branch, 91 miles in length, amounted for the past year to £186,710, and for the preceeding year to £148,460, showing an increase of £38,259, or 25·8 per cent.

RAILWAY TO CONSTANTINOPLE.—A project has been set on foot by an engineer named Dumont, to continue the present continental railway communication as far as, Constantinople. The present European network of railways extend as far as Bazias, a small port on the Danube, 650 kilometres (¼ of a mile each) distant below Pesth. The line from Paris to Bazias by Strasburg, Munich, Vienna, and Pesth is about 2100 kilometres in length, and the journey may be performed in sixty hours. This line of railway might be extended to the Black Sea and Constantinople in two directions; one by Belgrade, Servia, Bulgaria, and Roumetia, a line already surveyed by the English; and the other which would reach Constantinople by Roumania, passing by Crajova, Bucharest, Rustchuck, Schumla and Adrianople, crossing the Balkans at the most available point, in the neighbourhood of Aidos. This is Dumont's project. The total length of the proposed lines will be about 1500 kilometres, thus divided:—On the Austrian territory, from Bazias to the frontier of Roumania, near Orsova, 125 kilometres; from Orsova to Rutschuck by Bucharest, 353 kilometres; from Rutschuck to Constantinople by Schumla, Aidos, and Adrianople, 600 kilometres; giving a total from Orsova to Constantinople of 1,085 kilometres. Branches from Bucharest to Bazias and Galatz, and those from Cernavado to the foot of the Carpathians, would be altogether about 400 kilometres, making a total length of 1,485 kilometres.

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Works in Melbourne.—The great trunk line as far as Castlemaine and Sandhurst has been opened for traffic, but is not yet completed. It was opened a certain distance in April last, so that the portion opened is about fifty-seven additional miles. In this space some of the greatest engineering difficulties have been met with—two tunnels, each nearly a quarter of a mile long, besides several fine viaducts. Although the whole of the works have been executed in the most substantial manner, yet it does seem that some at least of the gradients need not have been so steep; Sandhurst being situate beyond the dividing range that had to be crossed; and this is done at an altitude of 1950 ft., within a distance of 45 miles of the sea level. One viaduct is of five spans, 130 ft. each, and 120 ft. high. This is over the valley of the Black Creek. That over the Coliban consists of five arches, each 60 ft. span, and 70 ft. high.

Railroads in Chile.—On the 3rd November last the third division of the Southern Railway of Chile was opened to San Fernando, the capital of the province of Colchagua, distant from Santiago 86 miles. The length of this extension is 34 miles, and the works have been designed and finished in a style alike creditable to engineer and contractor. The first passenger engine over the new works took down the President of the Board, the directors, and a large party of friends, who returned to Santiago much pleased with the day's trip. The general character of the earthworks is light, but there are several bridges of importance, and a very considerable number of small openings and culverts. The bridges are executed in a simple but solid manner, and are good examples of work. The girders were made in England, and the masonry is principally native labour, and is cut from a white or pink porphyry which is very abundant in the country. The Engineer-in-Chief, Mr. W. Cross Buchanan, was a pupil of Mr. Neil Robson, of Glasgow; and the gentleman who undertook and finished the contract is an American, well known on the coast for his activity and energy. He is also engaged on another contract, namely that of the Santiago and Valparaiso Railway, the works of which are being rapidly pushed on. The charter of the Southern Railway Company of Chile empowers them to carry on their line as far as the river Maule, and this, as well as a much further extension, is at present under consideration in the Camaras. In all probability the surveys will shortly be proceeded with, preparatory to contracts being entered into with an eminent English contractor, who, it is understood, has made very advantageous offers to the Chilian Government.

Portugese Railways.—Mr. Price the contractor, to whose execution the works on the South Eastern of Portugal Railway have been entrusted, has lately returned from Lisbon, and reports that he will be prepared to open 60 miles of that railway in the month of June next, and the remaining 20 miles shortly afterwards. It is stated that the works have been executed in a very superior manner, and that they give perfect satisfaction to the Portugese Government.

Traffic Returns.—The traffic receipts for railways in the United Kingdom amounted, for the week ending the 3rd of January, on 10,584 miles, to £483,396, and for the corresponding week of last year, on 10,193 miles, to £460,796, showing an increase of 391 miles, and of £22,600 in the receipts. The gross receipts on the following fourteen railways amounted, in the aggregate, on 7,268 miles, to £380,942; and for the corresponding week of 1862, on 7008 miles, to £364,713, showing an increase of 260 miles, and of £16,229 in the receipts. The increase on the Caledonian amounted to £202; on the Great Eastern to £1533; on the Great Northern to £1097; on the Great Western to £3222; on the Lancashire and Yorkshire to £139; on the London and North Western to £3318; on the London, Brighton, and South Coast to £663; on the London and South Western to £1334; on the Manchester, Sheffield, and Lincolnshire to £604; on the Midland to £3223; on the North British to £1135; on the North Eastern to £796; and on the South Eastern to £357; total, £17,624. But from this must be deducted £1395, the decrease on the Great Southern and Western, leaving the increase, as above, £16,229. The goods and mineral traffic on those lines amounted to £195,102, and for the corresponding week of 1862 to £187,237, showing an increase of £7963. The receipts for passengers, parcels, &c., amounted to £185,740, against £177,476, showing an increase of £8264. The traffic receipts on sixty-four other lines amounted, on 3316 miles, to £102,454; and for the corresponding week of last year, on 3185 miles, to £96,083, showing an increase of 131 miles, and of £6371 in the receipts. The total receipts of the past week show a decrease of £47,314, as compared with those of the preceding week, ending December 27.

RAILWAY ACCIDENTS.

Sinking of a Railway Viaduct at Clapham.—On the morning before the new year, an occurrence of a serious nature, though unattended with loss of life or bodily injury, took place near the Clapham station of the Metropolitan Extension of the London, Chatham, and Dover Railway. That part of the Metropolitan Extension Railway, which is to join the Victoria Station at Pimlico by a bridge across the Thames at Blackfriars with the Farringdon-street terminus, was opened some time back, from Victoria to the Elehpant and Castle. The second station on the line is that at Clapham, and at about 200 yards distant the line crosses the Clapham-road and the Bedford-road by means of iron girder bridges. Between these two bridges is a viaduct consisting of nine arches of massive brickwork standing in a field. All the structure appeared to be quite safe up to the evening before the accident, when there were slight indications in the parapet of a subsidence of one of the centre piers taking place. The officials of the company were at once apprised of the fact, and every precaution was taken for the safety of the public by watching, &c. About half-past six the following morning, the men on watch found that the pier began to sink rapidly, and before long it had subsided upwards of four feet into the earth, carrying with it the next pier, and, as a matter of course, the centre arch and portions of the arches on each side. Notwithstanding this great sinking and the manner in which a large portion of the brickwork had become broken up, the rails did not give way for some time. Information was at once sent up to the Victoria terminus, as a train was to leave at 7.25, and the working beyond Clapham was stopped. Almost immediately a large body of workmen were on the spot, and the traffic between the Clapham and Brixton stations having been suspended, steps were taken to shore up the arches on both sides of those damaged.

Accident on the Great Northern Railway.—About half-past eight o'clock on the morning of the 6th ult. an accident occurred near the railway station at Knottingley. At a distance of about 200 yards from the Knottingley station there is a junction of two lines of rails, one of them being from York and the other from Leeds. Parliamentary trains leave York and Leeds for London every morning, arriving at the Knottingley station, where they form one train, at half-past eight o'clock. Up to about ten minutes past eight on the morning of the accident the weather was fine and clear, but at that time it became suddenly foggy, and, at half-past eight o'clock, the time at which the trains were due, the fog was so dense that it was impossible to see more than a few yards. It was at that time that the accident happened. At about 130 or 140 yards from the station there is a bridge spanning the rails, and immediately beyond this there is a pointsman's and signalman's box. The junction of the lines referred to is some thirty or forty yards beyond, and at some distance down the lines there are signals by which the drivers of the trains are informed whether they can with safety approach the station. The two lines of rails are joined into one at the distance of a few yards from the pointsman's box, and it was just at the junction where the accident occurred. As was perfectly regular, the Leeds train proceeded towards the station first, and in the usual course the York train would have been signalled to approach when the line was clear, but unfortunately it ran forward before its time, became entangled with the Leeds train, and caused serious mischief. Neither of the trains was moving very rapidly at the time, or the consequences would have been most disastrous. As it was, when the carriages came into collision two or three of them were thrown off the line, and two of them were turned over and smashed. One of these carriages was empty, but several of the occupants of the other were very seriously injured.

Railway Collision near Liverpool.—A collision took place on the London and North-Western Railway, near Liverpool, between a passenger train and a goods train, on the 5th ult. Several persons sustained injuries; the severe concussion of the trains also causing considerable damage to the engines attached. The 12·30 (midnight) passenger train from Liverpool to Warrington had got so far as Whiston Bank, where there is an incline of about a mile in length at a gradient of about 1 in 80, and up which heavy trains have to be assisted by a bank-engine. When the train had arrived near the top of the incline the driver observed that he was dashing on to the bank-engine, which was in the act of pushing up a goods train. He immediately reversed his engine and endeavoured to stop, but could not do so in time to prevent the collision, which took place with great force. The passenger-engine's buffers were smashed to pieces, the buffer-plank and the iron framing of the engine were broken, and the tender of the bank-engine likewise very much damaged.

BRIDGES.

Opening of Lendal Bridge, York.—The opening of this iron bridge which has been erected over the river Ouse at Lendal, York, recently took place. The foundation stone of a bridge was laid on the 9th of October, 1860. As the bridge advanced, and its character became more prominently displayed, neither those who had seen the plans nor the general public were at all satisfied with the appearance it was likely to present. Circumstances attending the destruction of the bridge on Friday, Sept. 27th, 1861, very nearly a year after the foundation stone had been laid, will be in the recollection of many of our readers. One of the girders fell into the river, and the others were prostrated upon the bridge, five persons employed thereon being instantly hurried into eternity. The design for the bridge (which is after the style of the Westminster Bridge) presented by Mr. Page was ultimately adopted, and the contract for the iron work from Messrs. Hawks, Crawshay, and Co., of Gateshead, for £3600, was accepted by the committee. The bridge consists of a single arch of the Tudor style, has a span of 175ft. 2in., and is 25ft. in height from the summit level of the river to the crown. Six ribs of immense size are tied together with cross girders and braces tied and stayed, there being bearers for the corrugated iron plates which had been prepared for the girder bridge and which have been used up in the present bridge. The spandrils consist of castings of Gothic tracery ornamented with large shields of the city on one side, and the arms of the see of York on the other. The footpaths on the bridge are formed of the Hopton Ward stone, a beautifully white paving stone, which has been used at the Houses of Parliament. The extreme width of the bridge is 37ft. 9in.; the width of the footpaths, 8ft. 3in.; and the width of the roadway, 21ft. 3in. The weight of the bridge is at least 390 tons, and it is believed to be of sufficient strength to carry a railway train.

Westminster Bridge.—From a Parliamentary return just issued it appears that up to the 14th of last July a sum of £393,189 19*s.* 2*d.* was expended on Westminster Bridge. Of this amount, £145,057 18*s.* 5*d.* was paid to contractors, and £248,132 9*d.* to other parties. The amount expended on the approaches was £109,054 4*s.* 9*d.* The whole of the outlay has been supplied from property belonging to the Westminster Bridge Commissioners, and from votes of Parliament.

DOCKS, HARBOURS, &c.

The Metropolitan Board of Works have, by a majority of thirty-three votes to one, have resolved that the resolution of 1858, for erecting deodorising works at Fulham, should be rescinded. The engineer is to report on the best way of conveying the sewage of the western area into the northern low-level sewer. The Thames will thus be freed from one cause of impurity with which it was threatened.

The Great Iron Floating Dock built at Sourabaya, Java, from the designs of Mr. R. W. Thompson, C.E., has been successfully launched. The difficulties of launching such an immense structure were evaded by building it in a kind of dam made on the seashore. When the iron dock was completed the sea wall of the dam was broken, and the sea rushed in lifting the dock from the blocks on which it had been built. Messrs. Randolph, Elder & Co., of Glasgow, have lately completed a similar iron floating dock for the French Government. This structure is capable of lifting out of the water the largest man-of-war in the world, not excepting the *Warrior*, with all her guns and armour-plates in their places. This dock is also from the designs of Mr. Thompson.

GAS SUPPLY.

Gas at Aldershot Camp.—A portion of the permanent barracks at Aldershott have been lighted with gas from extensive works erected by the government on the banks of the Basingstoke canal. The gas supplied is said to be pure and good, and its introduction is regarded with much satisfaction by all ranks and branches of the service. The Gas-works, it is stated, were erected at a cost of £22,000.

The Worcester Gas Company's directors have announced a further reduction in the price of their gas, from 5*s* to 4*s.* 6*d.* per 1000 cubic feet.

BOILER EXPLOSIONS.

Manchester Association for the Prevention of Steam Boiler Explosions.—At the ordinary Monthly Meeting of this Association, held on January 6th, 1863, the chief-engineer presented his Monthly Report, of which the following is an abstract:—"During the past month, ending December 31st, 1862, there have been examined 430 engines—3 specially; 621 boilers—12 specially, 9 internally, 54 thoroughly, and 546 externally, in which the following defects have been found:—Fracture, 4; corrosion, 33 (1 dangerous); safety valves out of order, 13 (2 dangerous); water guages ditto, 24; pressure guages ditto, 9; feed apparatus ditto, 1; blow-off cocks ditto, 32 (1 dangerous) furnaces out of shape, 7 (2 dangerous); blistered plates, 1. Total, 124 (6 dangerous). Boilers without glass water guages, 6; without pressure guages, 16; without blow-off cocks, 27; without back pressure valves, 44. While I am happy to be able to report that no explosion has happened during the past month to any of the boilers under the inspection of this Association, the occurrence of five explosions in other quarters during that period has come to my knowledge. Each of these has been attended with fatal consequences, twenty-six persons in all having been killed, and upwards of thirty-two injured. Two of the exploded boilers were personally examined. The first of these explosions, and from which ten persons were killed and twenty-six injured, occurred at an iron works. The boiler was a horizontal one, of plain Cornish type, with a single internal flue, and a longitudinal steam chamber fixed above the shell. It was heated, as is common in such works, by the flames passing off from the iron furnaces, the flames of one of these passed through the internal flue in one direction, and those from two others passed outside the shell in the other direction. These furnaces were placed immediately at the ends of the boiler, one at one end and two at the other. The dimensions of the boiler were as follows:—Length, 25 feet; diameter of the shell, 5ft. 3in.; of the internal flue tube, 2ft. 3in.; thickness of the plates, three-eighths throughout, with the exception of the flat ends, which were half inch, and strengthened with gussets in the ordinary way. The wreck was so complete that scarcely a trace of the fittings remained; but they are reported to have consisted of two safety valves two and a half inches n

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diameter, a float and glass water guage; which latter, however, had been broken a short time previous to the explosion; while there remained on the ground the feed back pressure valve and the feed stop tap. The load on the safety valve was stated to have been 70 pounds on the square inch; but the boiler had not been fitted either with a steam pressure guage or with a tap for applying the indicator, so that no means had existed of checking the actual pressure when the steam was up. The rents in the boiler, as well as the flight of the parts consequent on explosion, were extremely complicated, and are difficult clearly to describe. Generally, it may be stated that the shell and internal flue tube had been completely torn asunder one from the other, and that each of the end plates, gusset stays and all, had been wrenched from both shell and tube. To go more into detail. The shell had been rent transversely into two parts, and the longitudinal steam chamber dismantled. The internal flue tube had collapsed and separated into four lengths, fracturing at the ring seams of rivets. The longitudinal seams which were at the sides of the tube ran in line from one end of it to the other, and the collapse which is usually vertical, was in this case lateral, and had brought these longitudinal seams from each side of the tube close together. This was the case in each segment of this disjointed tube. The end plates, which had been built in pieces, were separated at each of the seams, and disengaged from the shell and flue tube by shearing both rings of angle iron. One gusset adhered to the end plate, but in the main they were torn away from both end and shell. There were many minor fragments, which were completely curled or crumpled up. The cause of this explosion was attributed at the inquest to shortness of water, which, leading to overheating of the plates, had, it was supposed, on the re-introduction of the feed, resulted in a sudden and excessive pressure of steam. This was imputed to the carelessness of the engine tenter, and the jury found him guilty of manslaughter; in consequence of which he was committed to the next assizes for trial. There is good reason to question the correctness of the above conclusions, and to attribute the explosion to other causes than shortness of water and the negligence of the engine tenter. The pressure of seventy pounds to the inch, at which the safety valves were stated by the manager of the works to have been loaded, was excessive for a boiler of such construction; not so much so for the shell as for the internal flue tube, the latter not being half the strength of the former. This must have been the case even when the boiler was new and even if the tube was perfectly circular; but since the tube had been repaired, in consequence of overheating, and very frequently a good deal of straining occurs in replacing old plates; also, many tubes are found on actual measurement not to be truly circular, although nominally so; and had this been the case in this instance, its strength would have been considerably less than half that of the shell. In attempting to unravel the complicated rents produced in boilers on explosion, it is important to bear in mind that girder strains and leverages, the amount of which it is difficult to calculate, are induced in the plates as soon as the statical equilibrium is disturbed by the occurrence of a rent. Collapse of flue tubes has been found in other cases to break them up into short lengths at the ring seams, and to shear the end angle irons through at the roots, as was the case in this instance. Upon careful consideration of all the circumstances, to enumerate the whole of which would be tedious, there appears every reason to believe that the explosion resulted from the collapse of the flue tube consequent upon its inherent weakness, and not from shortness of water; while that collapse might have been prevented either by the introduction at the time of the construction of the boiler, of flanged seams, or hoops of T iron, angle iron, or other approved form, or else by the addition to the flue, since it was made, of angle iron hoops. "The second explosion was of a much simpler character than the one just referred to, and occasioned scarcely any damage to property. The boiler was of plain double-flued internally-fired construction, such as is in general use at cotton mills in Lancashire. Its length was 25ft. 6in.; the diameter of its shell, 7ft. 6in.; and of its internal furnace tubes, 2ft. 10in.; the thickness of the plates in both being, from three-eighths to seven-sixteenths. The fittings were complete as to number, as well as satisfactory as to condition, and all that was necessary with due care for safe working. The working pressure was stated not to have exceeded thirty-five pounds, and there was no reason to doubt the correctness of this, while the boiler was perfectly capable of working safely at a much higher pressure, as long as it was in good condition. On examining the boiler, it was at once apparent that it had not exploded either from excessive pressure or shortness of water, but from thinning of the plates through external corrosion, from which a rent occurred in the last ring of plates of the shell in the left-hand flue immediately above the brickwork on which the boiler rested, it being set on what are termed side walls. This rent extended longitudinally through the solid of the plate, throughout its whole width, from one ring seam of rivets to the other, but opened only a few inches transversely forming a slot, the edges of which were blown outwards into the form of lips. The plate at this part was reduced by corrosion to the thickness of a sheet of brown paper, and some pieces were broken off with the fingers by one of the jury as specimens. It may be added that daylight could be distinctly seen through the adjoining plate, which had not been disturbed from its original position by the explosion, but was completely eaten through by corrosion in the form of veins, so that either leakage must have been going on at this part for some time, which, however, it can scarcely be imagined could have escaped detection, or else the plate must have depended on a coating of scale, such as was to be found in other parts of the boiler, for keeping it tight. It is unusual for a longitudinal rent in a cylindrical shell to confine itself to such narrow limits as this had done, and the fact is to be attributed to the proximity of the end plate and the lowness of the working pressure. The rush of steam and water had blown up the upper part of the brickwork flue, but the boiler was not moved from its place, and no further damage to property appeared to have been done. The loss of life occasioned by the explosion resulted from scalding, the persons killed being in the boiler-room at the time. The corrosion which, as previously stated, was external, was caused by damp in the flue, the plates being most seriously affected for a considerable distance along the seating, in addition to the part actually rent. This was at once apparent upon entering the flues, where large cakes of oxide were readily collected. Competent inspection could not have failed to have detected the corrosion and prevented the explosion. The flues were stated to have been swept out about once a year only, whereas this should be done at least every three months, not only to prevent the loss of fuel that must result from an accumulation of soot, but also in order to afford an opportunity of examining the condition of the plates."

MINES, METALLURGY, &c.

COAL AND IRON WORKS IN RUSSIA.—Within the last two months a number of men have left the Dawlais and Rhymae Ironworks for Russia. A gentleman connected with the Government of that country, came over and selected some of the best workmen connected with these works, and the wages agreed to be paid them were from £12, to £20, per month, being double and treble the money they earned in Wales. It appears that large ironworks are about to be started in Russia, and, as metallurgy and iron-making are comparatively unknown, the far-seeing Muscovites no doubt thought it would be well to have some practical men from this country. One of the party is expected to return shortly, it having been determined to secure the services of a few Welsh colliers as well.

THE COPPER MINES OF SOUTH AUSTRALIA.—The Moonta Mine has declared a dividend amounting to £32,000, or £10, per share. A second similar dividend it is expected, will be declared in January. The Burra Mine has also paid another dividend of £5, on the original £5 shares, being the 50th dividend of 100 per cent, that has now been paid out of that mine. The first work on a practical scale for reducing ores by Rodda's patent process have been completed at the New Cornwall Mine, and a company is in process of formation for erecting more extensive works at other mines.

ON THE QUICKSILVER MINES OF CALIFORNIA, BY DR. L. FEUCHTWANGER.—Among the inexaustable resources of California, quicksilver is one of the most interesting and profitable, for the simple reason, that the cost of mining and extracting the metal from its ore, the cinnabar, is the least expensive of all the valuable and costly ores, such as gold, silver, and copper. The yield of quicksilver is from 70 per cent. down to 25 per cent., and the mode of separation is very simple. The new Almaden mine has sixteen furnaces, containing 20,000lbs. of the cinnabar, and two larger ones, containing 90,000lbs. of the ore, and producing daily 100 flasks of 75lbs. of quicksilver each. Having visited many localities in the month of May, 1862, I feel satisfied that quicksilver will, ere long, form an important item of export to every part of the world, for the steamer on which I left San Francisco had a considerable number of flasks for China, Mexico, and England; and with the increased demand in the Washoe district for the extraction of silver, the new gold placers of Victoria and Cariboo, and all the other cinnabar mines of the Sonama and Napa valleys, will likewise be put in requisition. The new Almaden mine has long been known to the Mexicans and Indians, the cinnabar, when ground fine, being called vermilion. It was made an article of traffic by the Indians along the coast as their red paint. From them the early white settlers of California learned the locality, and a Captain Castilero, of the Mexican service, registered the lands as his property, and formed a company for the purpose of extracting the quicksilver. Messrs. Bolton and Barron now hold the Castillero title, and an injunction which had been laid upon the mine for several years has been removed this year, and the mine is now their rightful property. From the magnitude of the mine, as well as of the smelting works, and the proper manner of operating, I feel satisfied that a more prolific mine does not exist anywhere. Along the range of these mountains, only three miles distant, is another quicksilver mine, called the Guadaloupe, which yielded considerable quantities a year ago; and the new Price and Enriquets mines, belonging to the same range of mountains, yielded 14,007 flasks of quicksilver in 1860. A very rich and extensive deposit of cinnabar, called the Aurora quicksilver mine, occurs in the quartz of Monterey. In Sonama county, in the vicinity of Mount St. Helena, near the famous Geyser Springs, a range of mountains, about ten miles in length, is found quicksilver ore in great abundance. The Pioneer mine is nearest the Geysers, and the pure metal may be detected everywhere running out from the rocks. Next comes the Pacific mine, which has likewise fair prospects for a solid and regular vein of the cinnabar. The Denver mine and the Dead-Broke mines have also the strongest indications of regular veins. In Knight's Valley, in Sonoma county, in Santa Clara country, in El Dorado county, are also found indications of regular mines; and in Mariposa county, at Phillips' Ferry, near the Stanislaus river, in the Mono diggings, a lead of cinnabar, thirty feet in width and seven miles long, has been discovered. At the Rogue and Klamatts rivers rich leads of quicksilver have also been discovered.

APPLIED CHEMISTRY.

HYDROGEN GAS.—Mr. Christopher Binks, of Parliament Street, proposes to obtain hydrogen gas by the decomposition of steam, such steam being passed through wood, charcoal, coal, or coke. It has hitherto been usual to heat the wood, charcoal, coal, or coke, and then pass the steam at the ordinary temperature through them, but as an improvement upon this, Mr. Binks proposes to superheat the steam, and keep it at a high temperature while it is passed through the wood, charcoal, coal, or coke, at an ordinary temperature, the result being that the hydrogen is more cheaply and readily produced.

ON THE FORMATION OF ACETYLIDE OF COPPER IN COPPER TUBES FOR CONVEYING LIGHTING GAS, BY M. CROVA.—It is well known, that copper tubes, long used to conduct lighting gas, have sometimes, during the cleansing of the interior, occasioned very dangerous and sudden explosions, occasionally proving fatal to the workmen. In one of the scientific reviews, an accident of this kind is recorded as happening at Philadelphia. Acetylide of copper having the property of detonating by an elevation of the temperature or by a blow, and the presence of acetylene in lighting gas having been recently proved by M. Berthelot, I have tried to ascertain whether acetylene, in presence of air, could combine with copper, and so form acetylide of copper. By passing a mixture of air and moist acetylene through a glass tube containing bright copper turnings, this metal tarnishes rapidly, assumes iridescent colours, and finally becomes black, but as this alteration takes place only on the surface of the metal, it is very limited. By using copper reduced by hydrogen, I extended the surface of the metal. A small quantity of metal was placed in two flasks containing a mixture of equal volumes of air and acetylene, and also in one of the flasks a drop of ammonia. The two flasks, well stoppered, their necks plunged in water, were left to themselves for two days, They were then carefully opened, and the water entering them absorbed nearly half the gaseous volume. The absorption seemed to be somewhat greater in the flask containing a little ammonical vapour. The copper turned black. After washing and drying, I found that it contained a notable quantity of acetylide of copper; for, heated with hydrychloric acid is disengaged acetylene, and thrown on a heated metallic plate, a louder explosion resulted than with pure acetylide, and without deposit of carbon. This difference will be readily understood, for the acetylide formed during my experiments, finding itself in presence of excess of oxide of copper, the carbon and hydrogen of the acetylide were entirely destroyed. It is evident that copper, in presence of air and acetylene, is spontaneously transformed into acetylide of copper containing excess of oxide. As lighting gas contains acetyline, a little air, and perhaps even some ammonical vapours, it is obvious that acetylide of copper may be formed in tubes which have served to conduct lighting gas.

ON THE PROMPT ESTIMATION OF THE SOLUBLE SULPHIDES CONTAINED IN CRUDE SODAS, BY M. H. LESTELLE.—Soluble sulphides, the formation of which in the manufacture of artificial soda cannot be entirely prevented, are of great importance when viewed in connection with the commercial value of this product. It is important, also, in the course of the manufacture, to determine frequently the relative proportions of sulphides contained in crude sodas. These estimations can be made rapidly and exactly by the following method, based on the insolubility of sulphide of silver, and the solubility of all the other argentiferous salts, in presence of ammonia. Prepare a normal liquid of ammoniacal nitrate of silver by dissolving 27·690 grammes of fine silver in pure nitric acid, adding 250 cube centimètres of ammonia, and diluting with water to bring the volume to 1 litre. Each cubic centimètre of this solution corresponds to 0·010 gramme of monosulphide of sodium. Then dissolve in water the substance to be analysed add ammonia, boil, and then add, drop by drop, by means of a burette divided into tenths of a cubic centimètre, the ammoniacal silver liquid, and a black precipitate of sulphide of silver takes place. When nearly all the sulphur is precipitated, filter, and into the filtered liquid pour a fresh quantity of silver solution, until, after repeated filtrations, a drop of this liquid produces only a slight opacity. The estimation is then at an end, and it is only necessary to read the divisions indicated by the burette, and to compare this number with that of the weight. To estimate very small quantities of sulphide, the argentiferous liquid must be more diluted, and so that each cubic centimètre corresponds to 0·005 gramme of sulphide. By this rapid method, which at most requires five minutes, I have estimated the amount of sulphides contained in the washings of soda and of artificial soda. By these means I have ascertained that the best sodas always contain from 0·10 to 0·15 per cent. of sulphide; while those submitted for too long a time to the action of fire, distinguished as *burnt sodas*, contain a proportion rising to 4, 5, and even 6 per cent. Such variations affect the qualities of sodas, and, consequently, th e washings destined for the manufacture of salts of soda. It is, then, necessary to make these estimations as frequently as possible. Moreover, the presence of chloride of sodium, sulphate, carbonate of soda, caustic soda, &c., makes no difference in the exactness, by reason of the solubility in ammonia of the precipitates given by these bodies with nitrate of silver.

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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 DECEMBER 24th, 1862.

3435 T. C Hiud—Generating carbonic oxide.
3431 S. Haslam & A. Eatough—Preparing cotton to be spun.
3432 G. H. Birkbeck—Instruments for surveying and levelling.
3433 J. Broadbent & J. Robinson—Opening and cleaning cotton.
3434 F. N. Gisborne—Indicating the speed of ships at sea.
3435 A. P. Tronchon—Fire-arms.
3436 J. S Smith—Looms for weaving.
3437 W. C. Galloway—Pianofortes.
3438 W. Henderson—Obtaining iron and steel from certain ores and residual products.
3439 W. Clark—Applying heat to the feet in boots and shoes
3440 H. Tewlvetrees—Washing machines.
3441 J. Fairless—Milking cows.
3442 R. Lakin & J. Wain—Spinning and doubling cotton.
3443 E. Stevens—Making bread, biscuits, and pastry.
3444 J. Taylor—Carding cotton.
3445 J. & W. Lord—Fluting rollers.
3446 J. H Johnson—Stamping paper.
3447 D. G. Hope—Obtaining and applying motive power.
3448 A. V. Newton—Skates.
3449 J. Platt & W. Richardson—Pulverising artificial manures and chemical salts.
3450 C. J Denton—Revivifying animal charcoal.
3451 R. Knox—Metallic pens.

DATED DECEMBER 26th, 1862.

3452 W. Clark—Fire-arms.
3453 C. F. Varley—Electric telegraphs.
3454 E T. Loseby—Ascertaining the pressure and the moving force of the atmosphere.
3455 J. Swainson—Pill boxes.

DATED DECEMBER 27th, 1862.

3456 W. H. Samson—Cultivating land by steam power.
3457 M. F. A. Courtois—Wax candles and torches.
3458 J. & S. Fr emantle—Propelling vessels.
3459 J. Petrie—Slide valves for steam engines

DATED DECEMBER 29th, 1862.

3460 M. Ker—Wardrobes.
3461 J. G. Taylor—Dress fastenings.
3462 J. H. Riddell—Pipes for conveying gases, fluids, or vapours.
3463 J. H. Riddell—Stoves.
3464 A. W. Sleigh—Making ships and batteries impenetrable.
3465 F. Tolhausen—Petroleum or coal oil as fuel.
3466 G. Haseltine—Cartridges.
3467 C. E. Wilson—Wearing apparel for the neck.
3468 W. E. Newton—Preserving organic substances from decay.
3469 W. Billinghurst & J. Requa—Portable battery.

DATED DECEMBER 30th, 1862.

3470 J. Johnston—Surface refrigerator.
3471 J. Robson, jun.—Fittings for stove grates.
3472 J. H. Johnson—Ingot moulds.
3473 H. A. Bonneville—Saddles.
3474 F B. Anderson—Watches.
3475 W. & H Bowser—Protecting iron and steel.
3476 W. Mould—Plaiting and measuring fabrics.
3477 J. E. Carter—Chimney tops.
3478 W. Richards—Fire-arms.
3479 W. Clark—Governing apparatus.
3480 C. Beslay—Steam engines.

DATED DECEMBER 31st, 1862.

3481 B. Bottomley—Doubling threads of cotton.
3482 W. B. Adams—Railways and tramways.
3483 F. Applegate—Woollen cloth.
3484 J. S. Smith & J. Hardman—Power looms.
3485 J. W. F. Field—Breech-loading fire-arms.
3486 W Clark—Arrangement of the parts of rail way trains and the application of power for their propulsion.
3487 J. M. Napier—Heating apparatus.
3488 F. Laques—Cases for pipes and cigars.
3489 E. Loret—Double weft forks.
3490 W. Maltby—Extinguishing fires.

DATED JANUARY 1st, 1863.

1 R H. Collyer—Paper.
2 W. H. Brown—Battery plates.
3 G. Allcroft—Pr sure and vacuum gauges.
4 M. E Bowra & A. E Francis—Elastic fabrics.
5 J. T. Smith—Obtaining motive power.
6 R Faulks—Traction engines.
7 J. J Southgate—Portable fire escapes.
8 J. Jones—Stiffening textile fabrics.
9 W. Soutter—Raising and planishing metals.
10 W. Robinson—Glasses for lamps.
11 J. E. Baker & J. Landan—Boots and shoes.

DATED JANUARY 2nd, 1863.

12 W. A. Dattin—Pipes.
13 F. C. Bakewell—Apparatus for burning oils.
14 C. Eyland—Buckles.
15 H. Lyon—Finishing and packing cigars.
16 A. Bamford, R Bromley, R. Taylor, & J. Lett—Looms for weaving
17 E T. Hughes—Producing designs upon velvets, cloth, furniture, and hangings.
18 W. H. Muntz—Attaching sheathing to iron and other vessels.
19 H. J. Sergeant—Dressing and finishing silk and other fabrics.
20 J. E. Dowson—Wrought metal piles, columns, and shafts.
21 R. C. Ransom—Reaping machines.
22 A. S. Bolton—Wire.

DATED JANUARY 3rd, 1863.

23 H. Jones—Steam engines
24 E Skull & R. Mesling—Chairs.
25 W. Philippi—Bearings and axle boxes for machinery, carriages, and railway rolling stock.
26 R. White—Purifying, bleaching, and refining oils and oily and fatty matters.
27 W Astrop—Paper.
28 C. B Clough—Curing smoky chimneys.
29 W. T. Smallware & C. B. Weaver—Covering steel for making crinoline skirts.
30 W. E. Newton—Firing cannon and fire-arms.

DATED JANUARY 5th, 1863.

31 E. B. Keeling—Lighting halls and theatres.
32 H. Yates—Shovels and spades.
33 J. A. Cooper—Substitute for silk, cotton, and flax.
34 J. Howard & J Bullough—Warping machines.
35 H. Blacklin—Preserving money, papers, or other property at sea in case of shipwreck.
36 A. Monnet—Twisting and throwing silk.
37 H. Bessemer—Pressing, moulding, embossing, shaping, crushing, shearing, and cutting metallic substances.
38 H. Chamberlain—Generating and condensing steam and evaporating liquids.
39 D. Nevin & W. Coppin—Clearing and separating the woody parts from flax and hemp.

DATED JANUARY 6th, 1863.

40 J. A. Munn & J. D. Cobb—Automatic walking dolls and other figures.
41 W. E. Newton—Magneto electric telegraphs.
42 C. T. Judkins—New alloys.
43 J. Eckersley—Spinning silk, cutting pile fabrics, and weaving fibrous materials.
44 J. Leigh—Treatment of gas produced by distillation of coal, cannel, bituminous shale, boghead, mineral oils, petroleum or other combustible substances, and obtaining certain products therefrom.
45 T. and T. Vicars, Jun., & T. Ashmore—Bread and biscuits.
46 J. A Knight—Printing presses.
47 M. Hodgart—Pressing cotton.
48 E. V. Gardner—Treatment of petroleum and mineral oils.
49 J. G. Dahlke—Bricks and tiles.
50 G. Turner—Making leather from waste pieces of leather.
51 J. Whitworth & W. W. Hulse—Ordnance.
52 J. H. Johnson—Rocket torpedos.

DATED JANUARY 7th, 1863.

53 J. Neale—Capsules.
54 P. F Cashin—Covering wire, crinoline steel, or hoops for skirts.
55 W. Crabtree & J. Crowther—Perching and dressing textile fabrics.
56 W S Bruce—Lucifer matches and fusees.
57 T. Storey—Compound waterproof and ornamental fabrics.
58 W. Clark—Advertising.
59 G. C. Grimes—Treating splints for matches.
60 G A. Huddart—Buttons.
61 T. Aveling—Traction engines.
62 G. Dowler—Match boxes
63 G. T Bousfield—Skate fasteners.
64 H. Harben—Cleaning machinery.
65 J. H. Johnson—Permanent way of railways.

DATED JANUARY 8th, 1863.

66 R. Grogan—Propellers for vessels.
67 L. Hull—Treatment of ground caoutchouc.
68 A. Guild—Breaking and cleaning flax and hemp.
69 C. Allen—Signalling on railways.
70 R. T. & R. Mouteith—dyes from aniline and its analogues.

DATED JANUARY 9th, 1863.

71 J. Punshon—Balance cylinder with counter-pressure, and the valves connected therewith, for stationary and locomotive steam engines.
72 C. Worssam—Lithographic press.
73 W. H Tucker—Locks
74 R. Thomas—Rendering hair wavy.
75 C. E. Gray—Wringing machines.
76 K. A. Goupil—Spherical wheel.
77 M. Cartwright—Alarums.
78 D. B. Parsons—Reaping and mowing machines.
79 E. T. Hughes—Printing woven fabrics, warps, and paper.
80 D Collings—Preparing cotton to be spun.
81 W. H Moreland & J. Chappell—Winding, warping, beaming, or dressing machines.
82 G. B Price—Sights for fire-arms.
83 W. Tasker—Harrows.
84 M. Henry—Furnaces.

DATED JANUARY 10th, 1863.

85 W. Grove—Sawing and cutting wood.
86 W. Grove—Sawing wood.
87 R. Lathy—Hydrostatic presses.
88 M. Vogt—Fastening for bags.
89 L. H. E. Lepreux—Hygrometric plates.
90 F. Fenton—Pulp for paper making.
91 E. Powers & J. G. Dale—Caustic soda and potash.

DATED JANUARY 12th, 1863.

92 D. Dawson—Magenta colour or dye.
93 E. D. Chattaway—Railway signals.
94 E. Stevens—Ovens, hot plates, and cooking apparatus.
95 W. Clark—Winding or copping frames.
96 W C rk—Carding engines
97 W. Clark—Green colouring matter.
98 A. L. Mahon—Screw, paddle, and submarine propellers.
99 W. E. Newton—Application of power deal ned for stationary and traction engines, propellers, and other machinery.

DATED JANUARY 13th, 1863.

100 T. G Lewis—Perambulators, invalid chairs, and other chairs
101 J. B. Penby — Apparatus to be attached to pianofortes, organs, and other similar keyed instruments for printing the score of any music performed on the said instruments.
102 T. Boyle—Comic stereoscope
103 D & J. Tannahill—Rivet-making machinery.
104 W. Platts & J. Bailey—Telegraphic cables.
105 J T. Stroud—Fixed and portable lights
106 C. H. Townsend & J Young—Compositions for preventing incrustation and corrosion in steam boilers and condensers.
107 R. A. Brooman—Lifting bobbins off spindles in spinning machines, and lubricating spindles.
108 W. Southwood—Nails or brads.
109 M. Tildesley—Padlocks and other locks and keys.
110 C. E Amos—Paper.
111 L. Lescuyer—India rubber overshoes.
112 T. Butler—Lace.
113 J. B. Rock—Saving life and property from fire and other danger in buildings and mines.
114 H. Bessemer—Treatment of malleable iron and steel.

DATED JANUARY 14th, 1863.

115 J. Kidd—Measuring the quantity of gas supplied to single burners, and increasing its illuminating power.
116 W. Pidding — Soles and heels of boots and shoes, stud nails, tips, and toe or other plates.
117 J. A. Schamberger—Colours for dyeing and printing.
118 J. S. Butler—Bobbin net made on bobbin net or twist lace machines.
119 G. T. Bousfield—Rolling, grinding, and cutting files.
120 G. A. Biddell—Pulping turnips and other vegetable substances.
121 B Burrows—Looms for weaving narrow fabrics.
122 J. Lawson—Holding castings and other pieces whilst being planed or shaped.
123 E. Morewood—Coated metallic sheets or plates and pieces.
124 Sweeping chimneys and preventing them from smoking
125 T Wilkinson—Tubular steam boilers.
126 W. Johnson—Chlorine and bleaching powder, carbonate of soda, and soda ash and sulphate of iron.

DATED JANUARY 15th, 1863.

127 H. Turner — Preventing and curing blight, decay, disease, and rot in potatoes, and other garden and farming produce.
128 W. Hulse & C. L. Haines—Taper metallic tubes.
129 E. Howes—Railway, ship, and other lamps.
130 T. C. Barraclough—Cutting metallic tubes.
131 T. C. Barraclough—Alarum apparatus.
132 J. Harrop—Treatment of organic fecal and urinous matters
133 G. Graham—Turkey-red dyeing.
134 R. Ferrier—Wet gas meters.
135 L. P. Josse—Cleansing wheat or other grain or seeds.
136 C. Murrell—Breech-loading fire-arms.
137 J. P. Bath—Carriages for tram and other roads.
138 C. H. G. Williams—Colouring matters.
139 J. W. Child—Spinning and weaving.
140 A. Prince—Sewing machines.
141 W. E Newton—Microscopes.
142 D. F. Leblanc—Level indicator or liquid gauge.
143 R. A. Brooman—Looms for the manufacture of lace and other fabrics.

DATED JANUARY 16th, 1863.

144 J. Kerr—Stopping railway and other carriages.
145 L. Verdure—Slubbing or rovings (in flax, hemp, and other filamentous materials), produced by the slubbing frame, and destined for fine spinning.
146 J. G. Winter & C. E. Gray—Vessels in which to cool and transport fatty or oleaginous matters
147 M. Morglen—Printing several colours in succession on the same surface.
148 E. Loysel—Preserving valuable property in cases of shipwreck.

DATED JANUARY 17th, 1863.

149 W. Shorrock—Power looms for weaving.
150 J Edwards—Buttons.
151 J. Lightfoot—Printing and dyeing textile fabrics and yarns.
152 I. Ashe—Preventing sea sickness.
153 J. Combe—Spreading, drawing, and carding flax and other fibrous substances.
154 G. Haycraft—Powder flasks.
155 G. T. Bousfield—Hot-air engines.
156 W. E. Newton—Buttons.

DATED JANUARY 19th, 1862.

157 E. Sabel—Artificial stone.
158 C. Norton—Roughing stone.
159 J. Laurie—Churning milk and mixing liquid compounds.
160 Sir W. O'Shaughnessy Brooke—Insulators for electric telegraphs.
161 H. Rushton—Plaiting cotton, thread, or other fibrous material over steels for crinolines.
162 R. A. Brooman—Sulphate of soda for conversion into soda
163 W H. Harrison—Covering wire and other iron articles for the purpose of protecting them from oxidation.
164 J. J. Lundy—Metallic casks and vessels.
165 B. Van der Mark—Musical instrument called mark-harmonica.

DATED JANUARY 20th, 1863.

166 A. Paul—Obtaining reciprocating motion in steam engines.
167 J. Mosheimer—Crushing and grinding quartz and other substances.
168 J B lli—Carding engines.
169 W. Mawson & J. Whitehead—Hydraulic machinery for raising water in mines, wells, and other places.
170 H. A. Bonneville—Clocks.
171 H. A. Bonneville—Colouring, bronzing, and preserving iron and steel.
172 M. Henry—Apparatus for retarding and stopping railway carriages.
173 W. Clark—Looms for weaving textile fabrics.
174 J. Smith & S. A. Cheese—Motive power engine.
175 H. Hughes & J. Sanders—Trimmings and cap fronts
176 S. Blackwell—Applying water or other fluid to the legs and other parts of horses and other animals.

DATED JANUARY 21st, 1863.

177 J. W. Messrs—Sash frames and sashes, and suspending the same by atmospheric pressure or otherwise.
178 A. Phillips—Looms for weaving figured fabrics.
179 T. Wright—Cast iron pipes.
180 F. A. Busch—Metallic vessels or receptacles for containing liquids or substances.
181 J. M. Kirk—Finishing textile fabrics.
182 H. B. Barlow—Jacquard machines.
183 J. Holt—Willowing and opening cotton and other fibrous substances.
184 A. Boubee—Casting or moulding articles in glass, and imitation of precious stones or marbles
185 W. Clark—Preparing and obtaining photogenic pictures and representations.
186 W. Clark—Desiccating and preserving matter from decay.
187 E. Bates—Legs.
188 C. H. Beeckner—Reducing wood to a fibrous condition, for the manufacture of paper stuff and pulp.
189 Sir C. Lindsay—Apparatus to be used on railways to indicate to the engine driver of a carriage train the length of time which has intervened since the passing of a previous train.
190 A. Pennington—Beating mats, rugs, and other like articles.
191 N. Clayton & J. Shuttleworth—Rotatory screens suitable for screening wheat and other grain or seed.
192 H. Care—Obtaining colouring matters.
193 H. Holcroft—Separating substances of different specific gravities.

DATED JANUARY 22nd, 1863.

194 W. Harrison & B. Crossdale — Looms for weaving.
195 J. C. Brandes—Hair creaser or divider.
196 J. Grant—Sidings and loop lines for railways or tramways.
197 J. Ellacot — Spur wheels, racks, and other toothed gear to insure greater strength in the teeth
198 J. M. Binger—Composition of a kind of pulp proper for the manufacturing of printing and typographical rollers.
199 R. Penney—Fixing colours employed in printing calico and other fabrics.
200 W. & J. Blackwood—Drying yarns or threads.
201 W. Clark—Piston-valves and other pistons.
202 N. Wood and J Stokley—Grinding, smoothing, and polishing plate glass
203 T Lambert — Drawing off water and other fluids
204 C Lungley—Facilitating the repairs of ships and other structures
205 F W Morley—Boilers for steam engines, and valves to be used therewith

DATED JANUARY 23rd, 1863.

206 J Milner—Steam engines
207 A Henderson—Textile materials
208 E Strangman—Pipes
209 C Stopford—Hats
210 F N Gisborne—Signals on board ship and indicating the position of the rudder
211 W Clark—Mariners' compasses
212 P A Cole—Collars, cuffs, wristbands, shirt-fronts, habit-shirts, and petticoats
213 C Turner—Felted fabrics
214—E T Hughes—Breech-loading fire-arms

DATED JANUARY 24th, 1863.

215 A O Glossop—Breakfast cruet, liquor, and other frames
216 W Mellor and W Whitley—Steam hammers and other engines driven by steam
217 W Allen and W Johnson—Grinding the cards employed in carding engines
218 R Shackleton—Looms for weaving
219 E and G Booth and A Swallow—Fixing colouring matter on cotton, silk, and wool
220 M A F Mennons—Punching and cutting metals
221 W Clark—Syphons
222 A J Sax—Rendering drum-skins and gut-strings less liable to hygrometric influences
223 R A Brooman—Anvils
224 F Tolhausen—Looms for weaving
225 F Tolhausen—Carding fibrous materials

DATED JANUARY 26th, 1863.

226 W F Stanley—Mathematical drawing instruments
227 J Barraclough—Railway engines
228 A Smith—Staples, locks, bolts, and latches
229 J Fyfe—Safety apparatus for steam engines
230 A L Lictout and J B Roisin—Gymnastical apparatus for medical purposes
231 R A Brooman—Petticoats or crinolines

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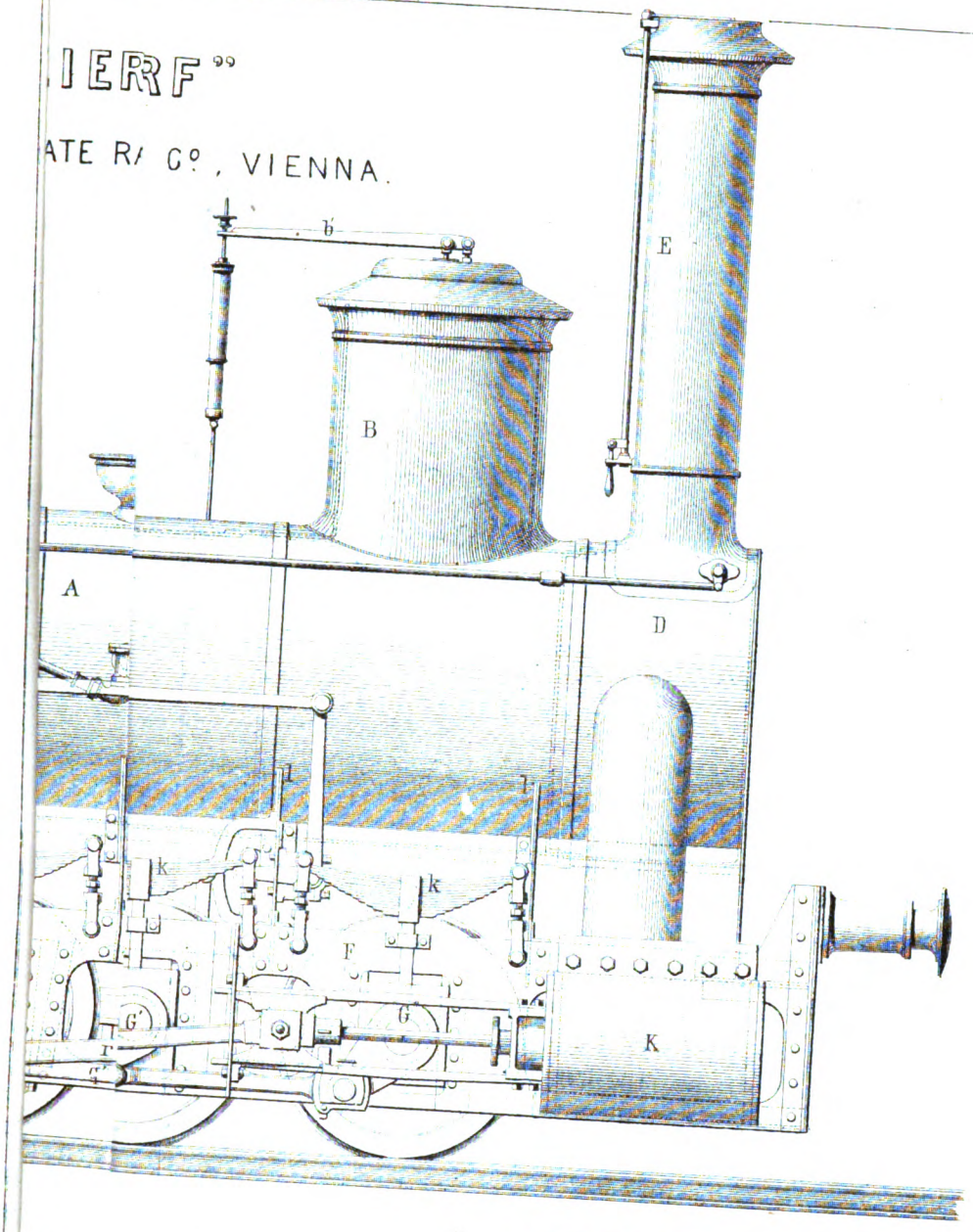

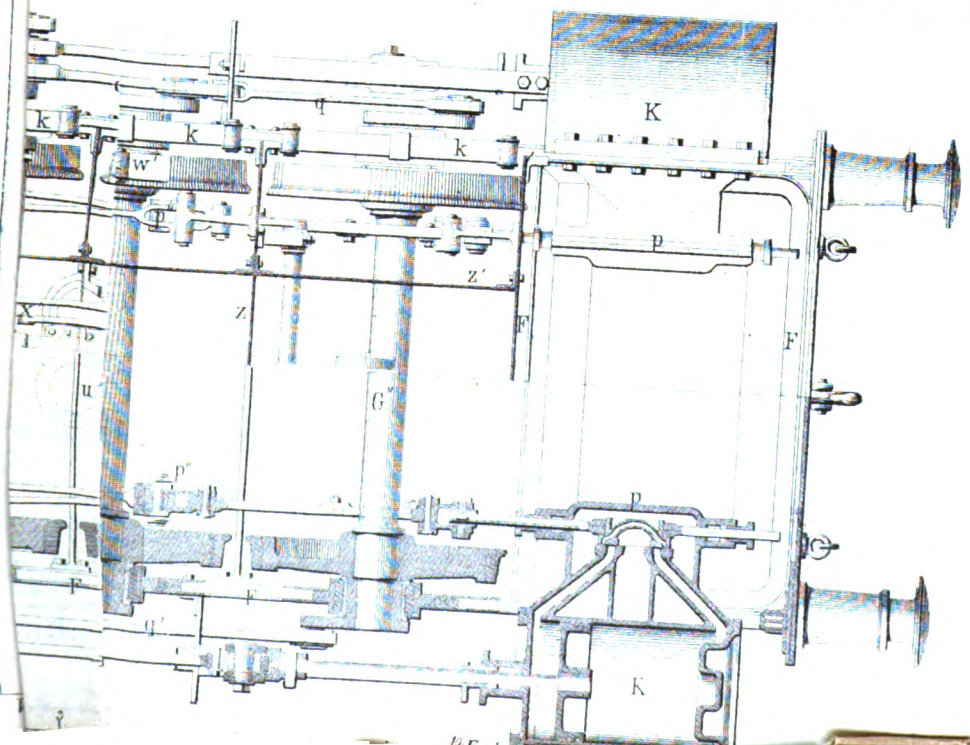

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